MINING engineering

FEBRUARY 1957

ANNUAL REVIEW NUMBER

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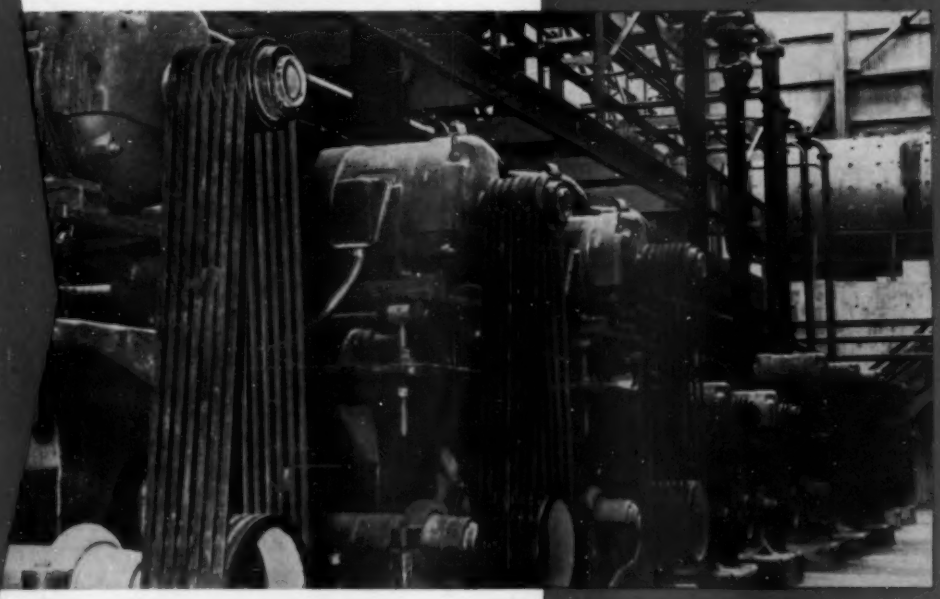

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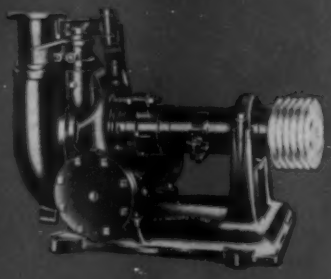

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MINING ENGINEERING

VOL. 9 NO. 2 FEBRUARY 1957

COVER

Current status in any technical field is the result of long growth, and a review can measure time precisely in only one respect: the time since the last review. New projects reported will be finished in future years; completed projects began in years past; and the knowledge that makes all of these possible began growing almost before there were instruments to measure time. The symbol: a sundial. Artist: Herb McClure.

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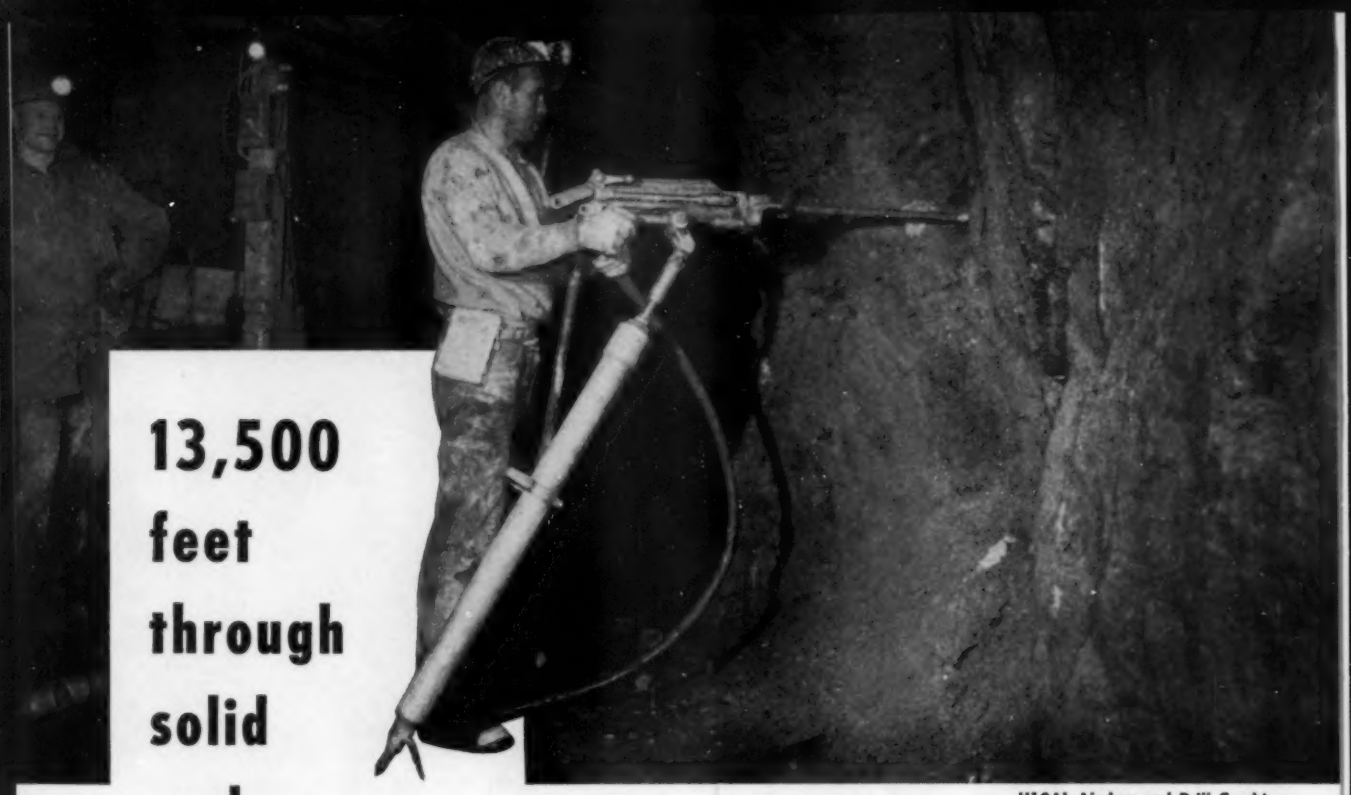

13,500 feet through solid rock...

H10AL Air Leg and Drill Combination at work. Note ease with which operator can adjust feed pressure.

yet maintenance cost only $48.00

Le Roi-Cleveland H10AL Air Leg, with superior construction and performance, keeps costs low.

Uranium mine reports increased footage, lower maintenance, when *Le Roi-Cleveland H10AL Air Leg and Drill Combinations are in use.*

Drilling an accumulated footage of two and one-half miles through solid rock is a real test of equipment. By keeping accurate records, one of the leading metal mines in the West found that the use of Le Roi-Cleveland H10AL Air Leg and Drill Combinations greatly reduced maintenance costs while increasing footage.

For drilling 13,500 feet of hole, this cost was only $48.00.

Ask the miner at the face. He may not be so directly concerned with overall operating and maintenance costs, but he will tell you that his work is easier and he gets more footage with a Le Roi-Cleveland H10AL Air Leg and Drill Combination.

The miner knows his tools; he takes pride in their performance. He favors too, the drill combination that makes his work easier so that he is less tired at the end of his shift. That means more work per man-hour and a major contribution to lower costs.

Easier-to-handle means more work per man-hour. Here are the reasons why the miner finds Le Roi-Cleveland H10AL Air Leg and Drill Combinations the easiest equipment to handle:

(1) Only Le Roi-Cleveland provides an air leg and drill with a built-in 11-position feed control — eliminating a third hose and cumbersome "Y" connections — reducing the weight he has to handle.

(2) The miner does not have to continuously bleed-off air to maintain suitable feeding pressure.

(3) He finds steel-changing easier, faster, with the new quick-opening steel puller.

Higher drilling speed regardless of varying rock conditions. Le Roi-Cleveland H10 Drill is one of the fastest drilling-sinkers made today. Combine this speed with the built-in feed control — providing 11 feeding positions from zero to full-line pressure, with an increase of 9-psi at each setting — and you have equipment with real production capacity and great stamina.

This is a feature that enables the miner to adjust the feed so that the drill is always down on the collar of the shank for maximum drilling speed, regardless of varying rock conditions.

Why maintenance is so low. Le Roi-Cleveland drills have stamina. They are built to take it. They stand up to the cruelest, hardest punishment that a drill can face — giving longer, better service.

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Moreover, the new steel-puller helps to reduce maintenance costs still further. Consisting of only five parts, with one spring, one plunger, it's lubricated from the inside to prevent wear and to wash out dirt.

High drilling speed with low upkeep cost make Le Roi-Cleveland Rock Drills the first choice in mining equipment.

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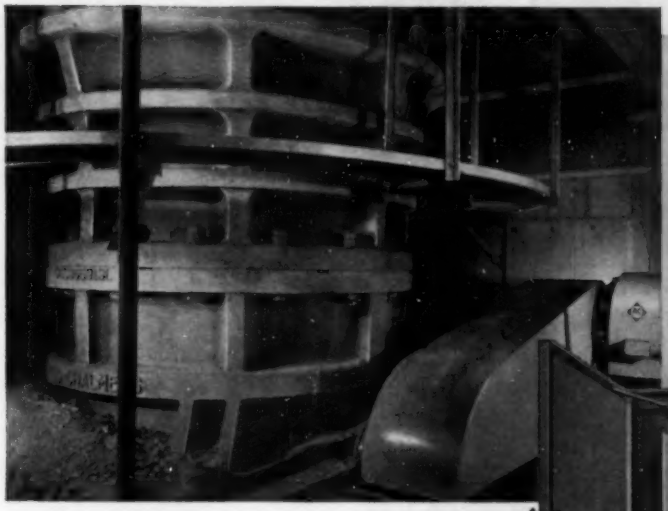
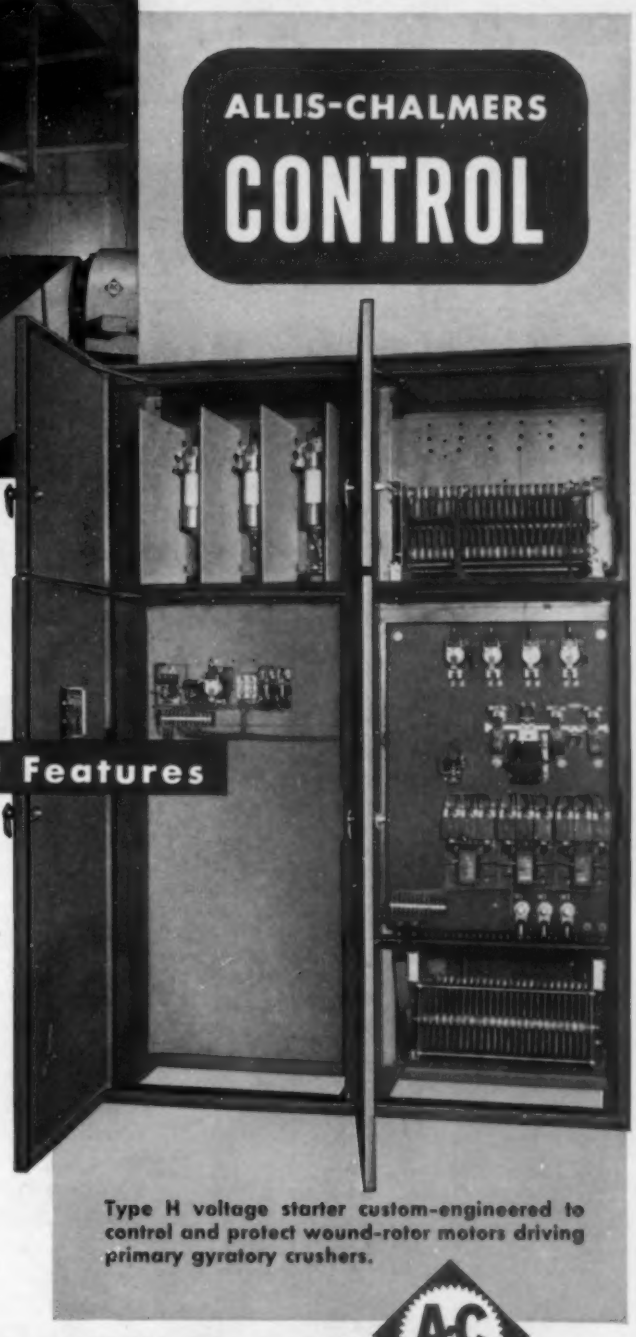
custom control cuts crusher downtime





As a leading builder of gyratory crushers for more than 75 years, Allis-Chalmers has expert knowledge of crusher control problems . . . and how best to solve them. Special controls for crushers, developed by Allis-Chalmers, offer important operating and protective features that minimize costly downtime . . . assure continuous, dependable operation.

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Control permits maximum torque starting, when desirable. Maximum torque starting often clears crusher jams.

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This feature permits rocking to clear jam.

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Crusher rides through momentary voltage dips.

Stall Protection
Motor is disconnected by instantaneous relay when current is greater than normal peak load.

For detailed information, contact your A-C representative, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

Type H voltage starter custom-engineered to control and protect wound-rotor motors driving primary gyratory crushers.

ALLIS-CHALMERS

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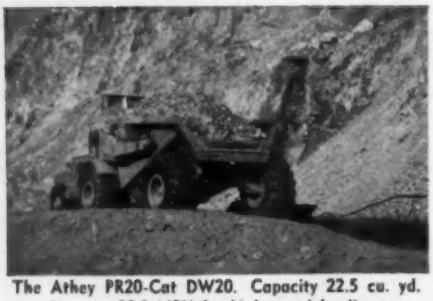

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The Athey PR15-Cat DW15. Hauls 22 tons of rock or other material at speeds to 31.3 MPH.

The Athey PR21-Cat DW21. 34 ton capacity, maneuverable for crowded areas. Standard or heated body.

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Athey

Joy 60-BH Drill in operation in a large Southwest copper mine.

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the JOY 60-BH Super Heavyweight Champion

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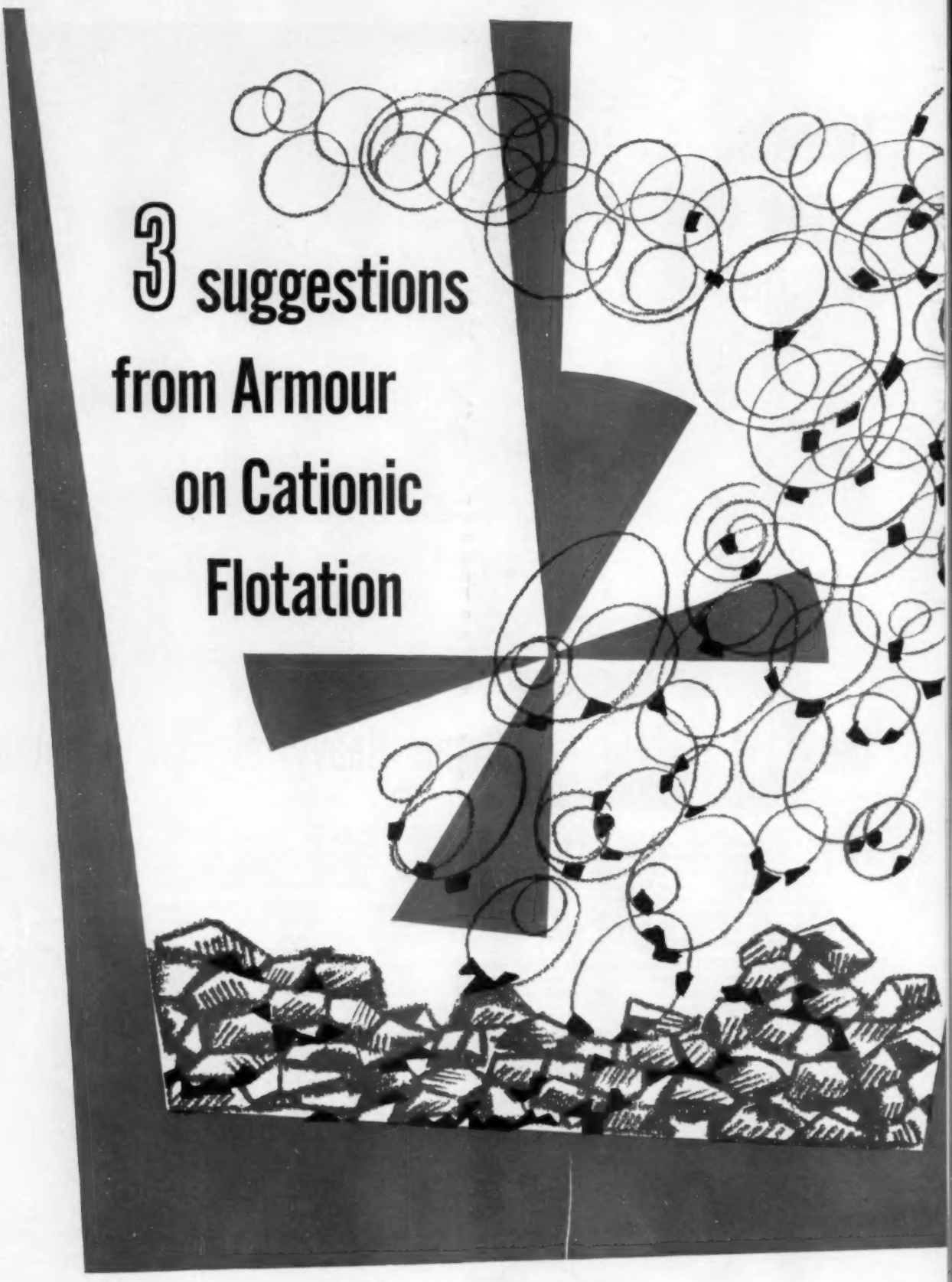
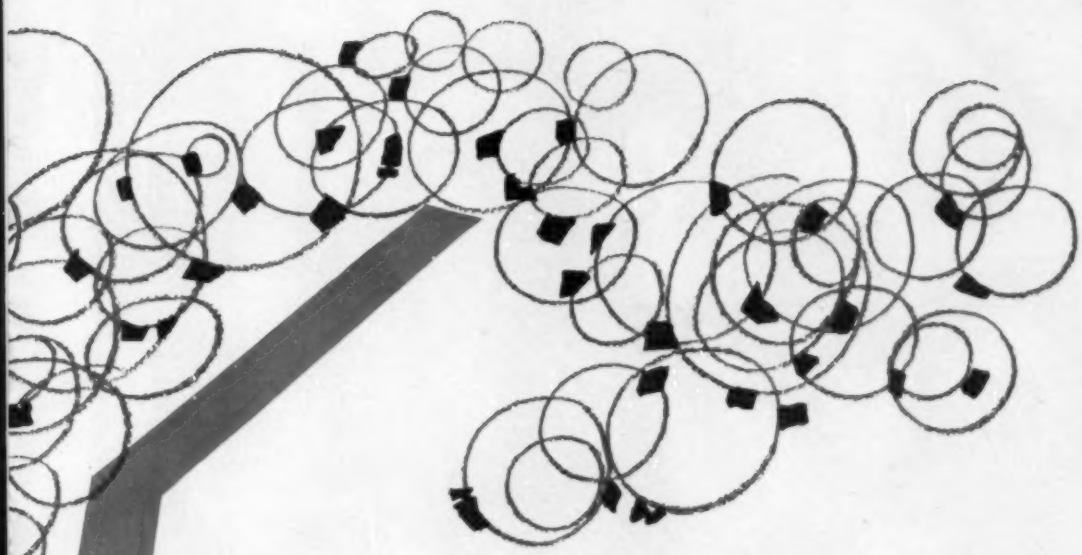
3 suggestions from Armour on Cationic Flotation





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0.80	0.20	6.27	29.62	59.9	77.9

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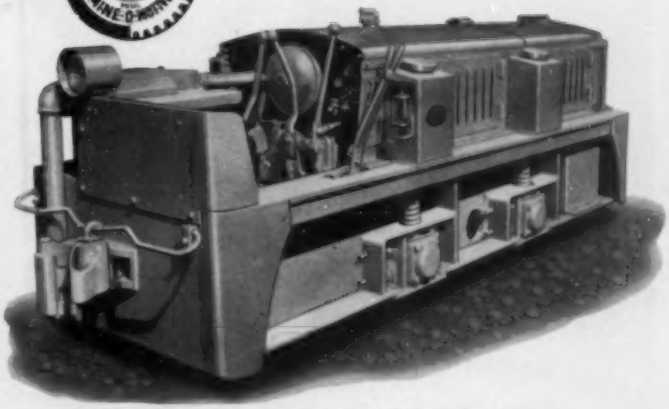

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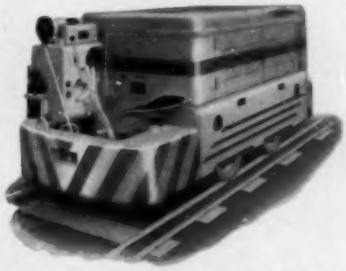
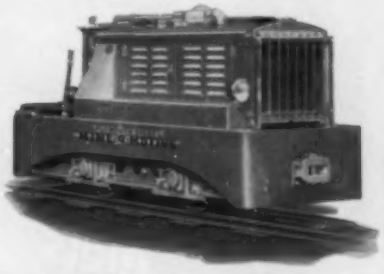
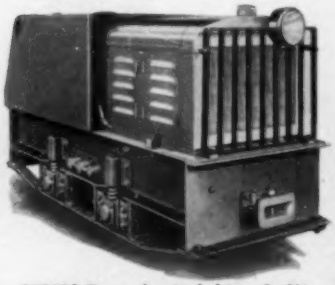
Model FMD-00 5 or 6 Tons, Torqomotive* Drive—short wheel base, low center of gravity.



MINE-O-MOTIVE SERIES Model FMD-22 5, 6, 7, 8 or 10 Tons, Torqomotive* Drive (this model approved under Permissible Schedule #22, U. S. Bureau of Mines, for operation in gaseous mines).



MINE-O-MOTIVE SERIES
Model DMD-00, 8 to 12 Tons, with Torqomotive* Drive — low, compact, one-piece welded frame.



SERIES T, mechanical drive, 3, 3½ or 4 Tons. Torqomotive* Drive in 3½ or 4 Tons.

*TORQOMOTIVE DRIVE: Plymouth Transmission coupled to Hydraulic Torque-Converter.

FREE ANALYSIS Send us a brief outline of your hauling operations. An engineering analysis will reach you promptly with latest data on the type and size Mine-O-Motive for the best results in the work you want done.

PLYMOUTH LOCOMOTIVE WORKS
Division of The Fate-Root-Heath Company
Dept. A-24, Plymouth, Ohio

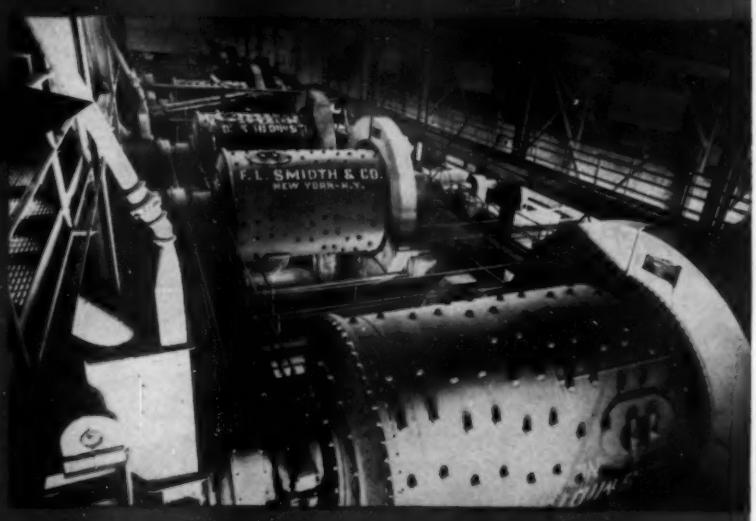
SMIDTH

Rotary Kilns

For sintering, nodulizing, calcining, desulphurizing, oxidizing and reducing roasting—coolers, precoolers, preheaters, recuperators—and auxiliary equipment.

Grinding Mills

Ball mills, tube mills and multicompartment mills—open or closed circuit—wet or dry grinding also airswept for grinding and drying.



Over 1,000 Smidth Rotary Kilns and over 5,000 Grinding Mills supplied all over the world.

F. L. Smidth & Co.
Engineers and Machinery Manufacturers
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New York 36, N. Y.

F. L. Smidth & Co., A/S
77 Vigerslev Alle
Copenhagen, Denmark

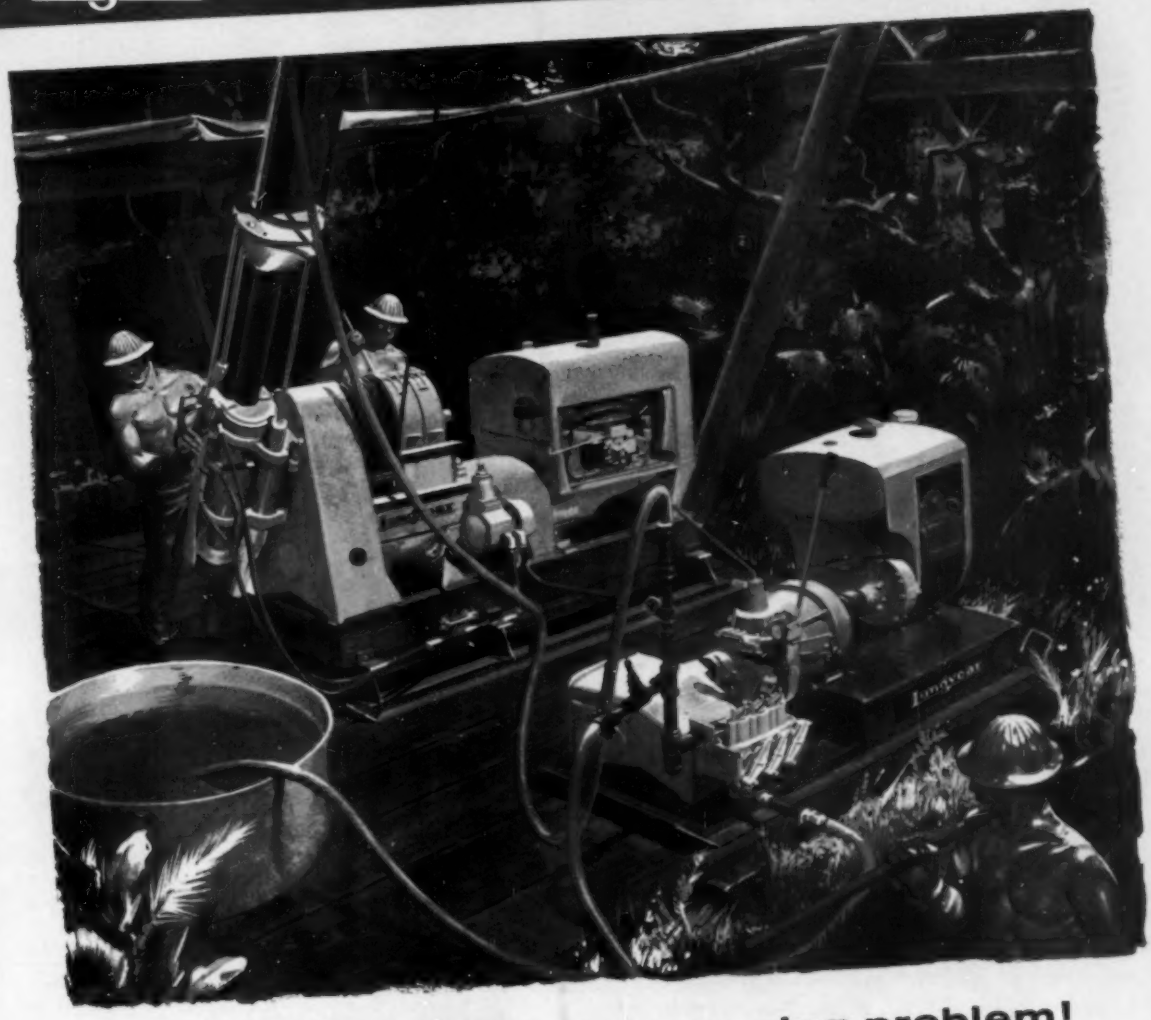
F. L. Smidth & Co., Ltd.,
105, Piccadilly,
London, W. 1, England

F. L. Smidth & Cie France
80 Rue Taitbout
Paris (9e) France

F. L Smidth & Co. of Canada, Ltd.
11 West 42nd Street
New York 36, N. Y.

F. L. Smidth & Co. (Bombay) Private Ltd.
42 Queen's Road
Bombay, India

Longyear



The drill crew **without a pumping problem!**

They depend upon the versatility of a Longyear transmission pump

Today this drill crew started a new hole, pumping as much water as possible through a rock bit. Next week, or next month, they may be pumping 5 GPM at 400-500 PSI and doing it *without bypassing . . . without throttling down . . . without changing liners . . . without changing pumps.* Rock bitting or fishtailing, coring at moderate depths or deep hole coring – their Longyear Transmission Pump satisfies *every* drilling condition.

The Longyear 535RQ Pumping Unit. This unit features a five-speed transmission—4.5 to 35 GPM's up to 500 PSI—Gasoline powered (also available with Diesel and electric power). Longyear transmission pumps feature stainless steel ball valves and valve seats—triple-coated hard porcelain steel-backed cylinder liners—Neoprene-impregnated fabric plunger cups.

Three Big Advantages

Because they selected a Longyear transmission pump, this drill crew has three important advantages. They:

1. Control pressure and vary water supply over a wide range by shifting gears.
2. Maintain proper engine speed to minimize carbon deposits, get maximum life from engine and pump.
3. Eliminate bypassing, can drill with a closed circuit.

Advantages of Closed Circuit Drilling

Closed circuit drilling permits the use of Longyear Wire Line or "L" series core barrels equipped with water shut off valve.

The instant a block occurs, increased pump pressure followed by discharge of water through the relief valve alerts the operator. This minimizes the chance of human error in detecting a block, substantially increasing core recovery.

The crew knows that the water is reaching the bit instead of escaping through a bypass – and bit costs are reduced. Fishing jobs brought about by burned or mudded bits are virtually eliminated. This one feature can more than pay for the pump.

A Longyear Pump For Every Need

Experience has shown that you can't overestimate the importance of *selecting the proper pump for the job.*

Longyear offers a complete line of pumping units for every drilling need. We will be happy to send you full information on our entire line of transmission and single-speed pumps.

Longyear

E. J. LONGYEAR CO. CABLE LONGCO
General Offices: Foshay Tower • Mpls. 2, Minn.

CANADIAN LONGYEAR LTD., NORTH BAY, ONT.
LONGYEAR ET CIE., PARIS, FRANCE

Diamond Core Drill Manufacturers • Core Drilling Contractors • Mining Engineering and Geological Consultants

THE WORLD IS OUR WORKSHOP

How a new **CAT*** No. 12 can

STEP UP YOUR MINE'S EFFICIENCY 3 WAYS

This new Caterpillar No. 12 Motor Grader maintains 16 miles of haul road and 'dozes truck spillage at the Hill-Trumbull Mine, Marble, Minn. It is owned by the Mesaba-Cliffs Iron Company and operated by the Cleveland-Cliffs Mining Company of Cleveland, Ohio. In building and maintaining haul roads for faster cycle times and reduced wear and tear on equipment, in 'dozing and clean-up work, the new Caterpillar No. 12 does a big and important job. Here is how it can do it at lower cost in *your* mine:

1. LOWER OPERATING COST. The new No. 12 delivers its 115 HP on non-premium, low-cost fuels. Its new oil clutch gives you longer clutch life, easier operation, and as much as 1500 hours between clutch adjustments. Tubeless tires (furnished at no extra cost) run cooler, last longer, and eliminate the tube and flap down time of old-fashioned tires.

2. LONGER WORK LIFE. Like all Caterpillar Motor Graders, the No. 12 is built—not just assembled—by a single manufacturer. This means traditionally sound Caterpillar ruggedness and workmanship, and careful balancing of engine and blade capacity for long life and high efficiency. And it means a single source for parts and service—your reliable Caterpillar Dealer.

3. INCREASED PRODUCTION. Positive, non-creep controls, easy "feel-of-the-road" steering, sure-footed traction with engine positioned over the driving wheels, quick-change blade positioning, unobstructed visibility—all these are good reasons why operators *like* the Caterpillar No. 12 Motor Grader, and do more efficient work on any job.

Your Caterpillar Dealer will demonstrate these and other features of the fast-working, long-lasting No. 12 Motor Grader. See him for proof that the Cat No. 12 will do more work at less cost on *your* job than any other grader.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

99% OF ALL CAT MOTOR GRADERS EVER BUILT ARE STILL AT WORK

Manufacturers News

News Equipment Catalogs

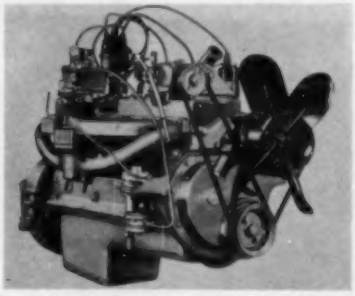
• FILL OUT THE CARD FOR MORE INFORMATION •

Belt Fasteners

Quick splicing of conveyor belts by use of Flexco belt fasteners and power tools is offered by *Flexible Steel Lacing Co.* A template positions bolts for rapid insertion and locking with the use of power tools. A boring bit and steel wrench are available for adapting the method to standard electric or air impact tools. **Circle No. 1.**

Heavy Duty "6"

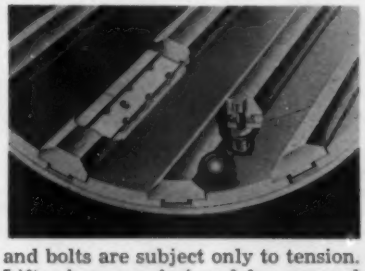
Industrial Engine Dept., *Willys Motors Inc.* has developed a new Jeep heavy duty 6-cyl engine for industrial use. Key points are reinforced for ruggedness, and design is intended to produce high torque at



low speeds. Four-ring aluminum pistons each have one compression ring and one oil ring of full hard chrome steel. New manifolding and single barrel carburetion permit economical operation, and compression ratio of 6.9 to 1 provides good performance with standard grade fuels. **Circle No. 2.**

Mill Lining

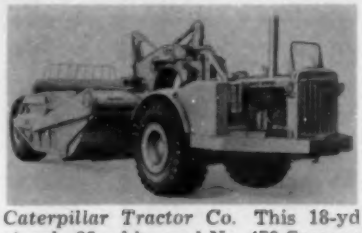
With renewable lifter bars and patented abutment strips made from Oroloy steel, *Kensington Steel Co.'s* new ORO-Lok lining for cement and ore-grinding mills claims longer service life. Lifter bars touch against liner plates which touch against abutment strips that absorb lateral stress,



and bolts are subject only to tension. Lifter bars are designed for removal or reversal and need no zincing or grouting in. Not enough abrasive material can enter behind the rolled steel liner plate to cause serious scouring. **Circle No. 3.**

Cat Scraper

Larger loads in less time are now possible with such large fast earthmovers as the Lowbowl scrapers by



Caterpillar Tractor Co. This 18-yd struck, 25-yd heaped No. 470 Scraper is matched to the Cat DW21 rubber-tired tractor. **Circle No. 4.**

Shaft Jumbo

Ingersoll Rand's new Hydra-Boom shaft jumbo can be designed to fit any shaft size and set-up takes about 15 min. Time saving is due to rapid-lock mechanical rib jacks, center

post stabilizer, single hose connection, convenient controls. Other advantages claimed—good control of hole pattern and direction, good fragmentation, capacity for large drills. Instead of benching, complete rounds may be drilled. A metal canopy protects against falling objects. **Circle No. 5.**

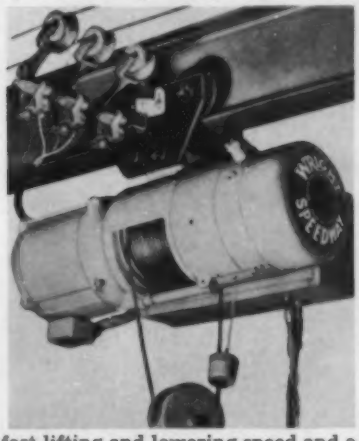
Self-Dumping Granby

Sanford-Day Iron Works Inc. has developed a hydraulic self-dumping Granby-type car that needs no fixed dumping point. Each Granby dumper is activated by a pair of hydraulic

cylinders. These are powered by a unit mounted on a small car coupled to the dumper. The cylinders raise the body to an angle of 40° in less than 30 sec. Selective dumping is possible and the cars have a capacity of 10 tons. Dimensions of unit shown are about 17x7x4 ft. **Circle No. 6.**

Electric Hoist

Wright Hoist Div., *American Chain & Cable Co. Inc.* has the 2-speed Wright Speedway electric hoist which is claimed to parallel control sensitivity of air hoists. Fractional hp 1800/450 rpm motors provide a



fast lifting and lowering speed and a ¼-normal speed for slow work. Oil bath-immersed automatic brake assures uniform operation and safe holding of load. Brake lining wear is compensated for by two simple adjustments of a set screw. Side and end housing covers may be easily removed. **Circle No. 7.**

Crawler Drill Rig

Drill, mast, and air power unit are mounted for one-man operation in *Thor Power Tool Co.'s* new MM-2 Drillcat. Unit consists of a 105M Drifter rock drill and the BW-2

wagon drill mast mounted on crawlers equipped with twin reversible 7.5-hp air motors. New rig is 6 ft 9 in. long and 6 ft wide; it weighs 3000 lb. Boom length is 3 ft 8 in. **Circle No. 8.**

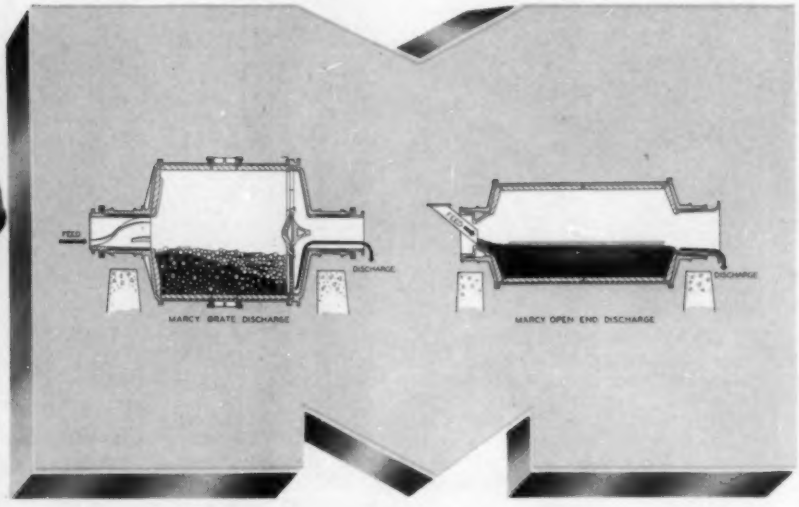
News & Notes

DeZurik Shower Co. of Sartell, Minn., is marking its 25th year in business and announces a change of name to *DeZurik Corp.* Renaming also coincides with placing substantial manufacturing and testing additions into operation. DeZurik's primary product is an eccentric-type non-lubricated plug valve available in a size range from ½ in. to 20 in.

see what Marcy can do for YOU!

MARCY PRINCIPLE OF GRINDING INCREASES TONNAGE UP TO 33%

"Rapid change of mill content is necessary for high efficiency"... that's the Marcy principle of grinding. It is accomplished by use of **full-grate** discharge on Marcy Ball Mills and the **open-end** feature on Marcy Rod Mills



This results in a low pulp line which...

- eliminates wasteful cushioning action of high pulp level.
- provides an active, effective grinding mass to work on particle size reduction only.
- results in faster migration of fines than oversize particles, thus less overgrinding.

In seven representative installations where overflow mills were converted to Marcy Grates the average increase in tonnage was 33.6% with an average decrease in power of 0.95 KWH per ton.

NO EXTRA CHARGE FOR MARCY EXPERIENCE

THE MINE AND SMELTER SUPPLY CO.

DENVER NEW YORK SALT LAKE CITY EL PASO

SALES AGENTS AND LICENSED MANUFACTURERS THROUGHOUT THE WORLD

(21) INTRA-SET DRILL STEELS: Carbide-tipped Intra-Set drill steels find much use in drilling rock bolt holes and small blast holes. Bit and steel are one piece. *Brunner & Lay Inc.* is the only maker of 4-point-bit steels of this kind, and they also offer a chisel type. Prices and sizes are included in 4-page Form 1S756.

(22) CONICAL SCRUBBERS: *Hardinge Co. Inc.* has available a variety of conical scrubbers for slurrying soft fractions of ore to be upgraded. Hardinge scrubbers consist of gear-and-pinion-driven cylindro-conical drums into which feed is introduced in a ratio of about one part water to one part dry solids. Sizes are from 6 to 13 ft diam with capacities up to 1000 tph, depending on requirements.

(23) BIT & ROD SHOP EQUIPMENT: Bit and rod shop equipment for fast economical bit and steel reconditioning is needed in many large scale rock drilling operations. *Ingersoll-Rand* offers a complete line of Jackbit grinders for all sizes of Carset bits and small steel bits. Included are steel and bit furnaces, sharpeners, cutter, and shank grinders. Also offered are air-motor-driven bench and hand grinders in Form 4187.

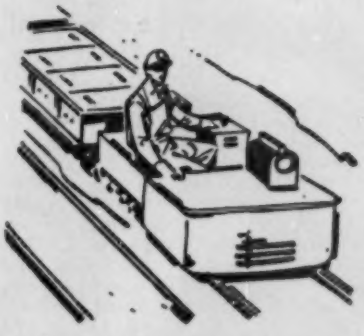
(24) MAGNETIC SEPARATORS: Catalog 910 from *Jeffrey Mfg. Co.* has latest data on several models of drum-type magnetic separators. Included are 2-drum styles for heavy media plants, and others for special applications such as taconite processing. Minimum supervision is required.

(25) T-1 STEEL: "Mining's Metal" is a new booklet from *U. S. Steel Corp.* which gives on-the-job accounts of T-1 construction steel in building and repairing mining machinery and equipment. T-1 is claimed valuable for mining applications as it is readily weldable and able to withstand hard impact and abrasion even when temperatures dip to —20° or —30°.

Free Literature

(26) DISC FILTER: *The Eimco Corp.* stresses the uniformity of product that results when the Agidisc disc filter is put to work. "Strong, properly directed agitation" is said to result in uniform cake dryness, cake thickness, particle dispersion, and tonnage consistent with feed.

(27) MINING BATTERIES: *C & D Batteries Inc.* has released a specification bulletin, ML-567/56, covering a complete line of batteries for mine



locomotives, trammers, shuttle cars, and tunnel haulage equipment. Specifications include data on battery ratings and capacities, design and construction details, dimensions, and weights.

(28) INDUSTRIAL LIGHTING: Available from *Sylvania Electric Products Inc.* is a new industrial lighting booklet, "Prescribed Lighting Protects the Eyes of Industry." Featured are sections on safety and visibility factors, standards for use in prescribing lighting, maintenance, and a condensed catalog of fixtures.

(29) COAL DUST CONTROL: Booklet 551-D from *Wheelabrator Corp.* discusses the use of local exhaust ventilation and cloth-tube type dust collectors in coal and coke-handling operations. This method is applicable to such operations as: conveying and preparing coal for burning in industrial plant or power plant furnaces; conveying, screening, and weighing of coke for charging foundry cupolas; and conveying, screening, crushing, weighing, and batching coal for chemical processing. Four illustrated case histories are presented.

(30) COMPUTING DEVICE: Catalog C80-1 from *Minneapolis-Honeywell Regulator Co.* describes the Sorteberg Force Bridge, a computing device which can be used in pneumatic measurement or control circuits for square root extraction, ratio setting, division, multiplication, squaring, and pressure or temperature compensation.

(31) EARTH DRILL: The McCulloch earth drill is a complete portable unit by *Soiltest Inc.* With a 6-in. auger, the drill weighs 87 lb. Ample power is claimed for fast digging in any earth, including clay. When drilling to depths of 20 to 40 ft auger rotation can be reversed to make removal easy.

(32) CHEMICALS: Detailed information on the entire line of Solvay alkalies and chemicals is offered in a new 56-page book by Solvay Process Div., *Allied Chemical & Dye Corp.* Included is data on uses, markets, properties, packaging, storage, and handling. Photos cover manufacturing operations at various Solvay plants.

(33) DRILLING TOOLS: *Brunner & Lay* products are featured in new 20-page Catalog 756 which includes carbide rockbits, drill steels, and pneumatic tool accessories. Suggestions are included for obtaining the best drilling results with carbide Rok-Bits.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

2

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Apr. 15, 1957—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

Name_____ Title_____

Company_____

Street_____

City and Zone_____ State_____

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64						

Students should write direct to manufacturer.

(34) FLUORESCENCE ANALYSIS CABINET: A compact fluorescence analysis cabinet is available from *Ultra-Violet Products Inc.* Mineralab is a selfcontained unit for laboratory or field use that measures 14x12x14 in. Cabinet contains both short and long wave ultraviolet lamps as well as white light for comparison purposes, all push-button operated.

(35) DIATOMS IN ARIZONA: Extensive deposits of diatomaceous earth in the state led the *Arizona Development Board* to commission a field and laboratory report on its occurrence. "Diatomaceous Earth in Arizona" is the 28-page result. Maps, photos, and tables supplement a complete technical report.

(36) ROCK DUST CONTROL: Specially engineered systems of controlling dust in rock crushing plants are described in a brochure from *Johnson-March Corp.* Described is the suppressing system for use at truck dump, crushers, screens, bucket elevators, conveyor transfer points, and storage pile.

(37) GYRATORY CRUSHER: *Traylor Engineering & Mfg. Co.* has a bulletin detailing features of the new TF fine reduction crusher. Designed for economical production of 5/16 to 1¼-in. material in large volume, the TF features less headroom requirement, spring suspension to protect shaft from tramp iron, bronze-bushed eccentric, forced feed lubrication, non-chokable bell head. Four head diameters are available—1 ft 8 in., 2 ft 4 in., 3 ft, and 4 ft.

(38) NO-CORRODE EQUIPMENT: A 32-page catalog of corrosion-resistant plastic equipment lists latest materials from *Haveg Industries Inc.* Offered in Catalog C-14 are: pipes, fittings, valves; fume ducts and systems; tanks, towers, accessories; heat exchangers; pressure and vacuum equipment; agitators. Data is included on chemical-resistant cements and field construction of plastic equipment.

(39) WET & DRY GRINDING MILLS: Six-page Bulletin AH-474 from *Hardinge Co.* covers major types of Hardinge reduction mills for both wet and dry grinding and pulverizing. Brief descriptions on tricone, rod, cylindrical, tube, batch, conical, and disc-roll mills are given with data on grinding mill accessories and classifying devices.

(40) PROTECTIVE COATINGS: A 32-page full-color manual from *Rust-Oleum Corp.* is intended as a guide for all users of metal-protective coatings. Data and color chips are given for: primers; indoor and outdoor short oil coatings for use where

dampness, salt air, fumes, and abrasion are present; and long oil type coatings for use in normal smoke, gas, and weather conditions. Technical descriptions are included of coatings for machinery, implements, mills and plants.

(41) POLE BUILDINGS: *Dow Chemical Co.* says that pole-type buildings are cheaper to construct yet are attractive, flexible in design, wind resistant, and sturdy. A booklet "Low-Cost Pole Buildings for Industry" illustrates uses and shows how pole-type construction gives needed space at minimum cost.

(42) PIT FURNACE: A new pit furnace from *Hevi-Duty Electric Co.* will do nitriding, bright tempering, steam tempering, annealing, and bluing and can be used with or without a protective atmosphere at temperatures to 1450°F.

(43) ACID HANDLING: Instructions for the safe unloading and handling of sulfuric acid are presented on a new 17x22-in. wall chart from the Industrial Chemicals Div., *Olin Mathieson Chemical Corp.* It describes proper methods for pump unloading and air unloading of tank cars, with special attention to cold weather procedure. Diagrams of piping arrangements are shown for both methods.

(44) SOLVENT RESISTANT GREASE: A new grease said to be impervious to the washing action of almost all petroleum and chlorinated solvents is available from *Pennsylvania Refining Co.* Claimed unaffected by naptha, kerosene, gasoline, LP gas, fuel oils, coal tar solvents, trichlorethylene, perchlorethylene, and orthodichlorobenzene the lubricant retains its consistency in use and may be pumped at low temperatures in a hand grease gun.

(45) CORROSION-PROOF VENTING: *American Agile Corp.* has a 12-page brochure covering items for corrosion-proof ventilating and exhaust systems such as centrifugal fans, ducting, hoods, fittings. Based on a year of testing, all data is presented in chart form.

(46) JAW CRUSHERS: Series WRB overhead eccentric jaw crushers by *Universal Engineering Corp.* are detailed in Folder Bu 117-561. Available in a wide range of sizes, the units feature extra long reversible manganese steel jaws, oversize roller bearings, one-piece welded steel base, high reduction ratio, easy adjustment for product size.

(47) ARMORED CABLE: *National Electrical Products Corp.* has a 24-page bulletin, "Nepco-Lok Interlocked Armored Cable, Supports, and Fittings," which details single and multiconductor cables available for voltages up to 15,000 v.

(48) MAGNETIC SHIELDING: A 33-page technical brochure describing construction features, performance characteristics, and typical applications of non-shock-sensitive non-retentive magnetic shielding material is offered by Magnetic Shield Div., *Perfection Mica Co.*

(49) STATIONARY DIESELS: Bulletin 108 from *White Motor Co.* describes the Model 40 stationary diesel engines which may be used in dredges, quarries, oil fields. Incorporated is a constant pressure lubrication system, increased pump capacity, improved pump drive, and a constant flow cooling system.

(50) DRIP-PROOF MOTORS: Latest design features of *Allis-Chalmers* open drip-proof motors in NEMA rerated ratings of ½ to 40 hp (Type G) and in non-rerated ratings of ½ to 100 hp (Types AP and APWW) are described in a new bulletin.

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BUSINESS REPLY CARD
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

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MINING ENGINEERING

29 WEST 39th STREET

NEW YORK 18, N. Y.

NEW THOR SELF-PROPELLED ONE-MAN DRILLCAT

First on-the-job reports prove Drillcat delivers more work, bigger profits, in less time

CHECK THIS PROOF DIRECT FROM THE JOB

PAID FOR ITSELF IN ONE JOB

A net profit of $15,000 in one week on rock drilling jobs was reported by one contractor—another, equipped with five Thor Drillcats paid for them in three months from extra profits.

SAVES OVER 2½ HOURS SET-UP TIME

You can set a Thor Drillcat in drilling position—ready to go—in 20 to 25 minutes.

FAST WHEN THE GOING IS TOUGHEST

One man on a Drillcat tugged a 600 c.f.m. air compressor ½ mile over rough terrain, drilled five holes and was back with equipment at his starting point in only two hours.

DRILLING TOE HOLES. The Thor Drillcat is completely flexible. The boom and mast are lowered flat to the ground for toe and lifter holes. Twin reversible drive air motors permit easy maneuvering to any position, any angle. (Note position of controls for easy operation.) A "dead man" control for all air valves is standard equipment on the Drillcat.

DRILLING DOWN HOLES. Two 7½ h.p. air motors propel this compact (6 ft. 9 in. overall) Thor Drillcat where no other crawler can go. More than enough power to pull its own air supply. Drilling down holes is no chore for Thor's Drillcat. Using the powerful model 105M drifter and chain feed mast, the hydraulic accumulator keeps boom rigid at all times. This means less steel breakage and less wear on chuck parts.

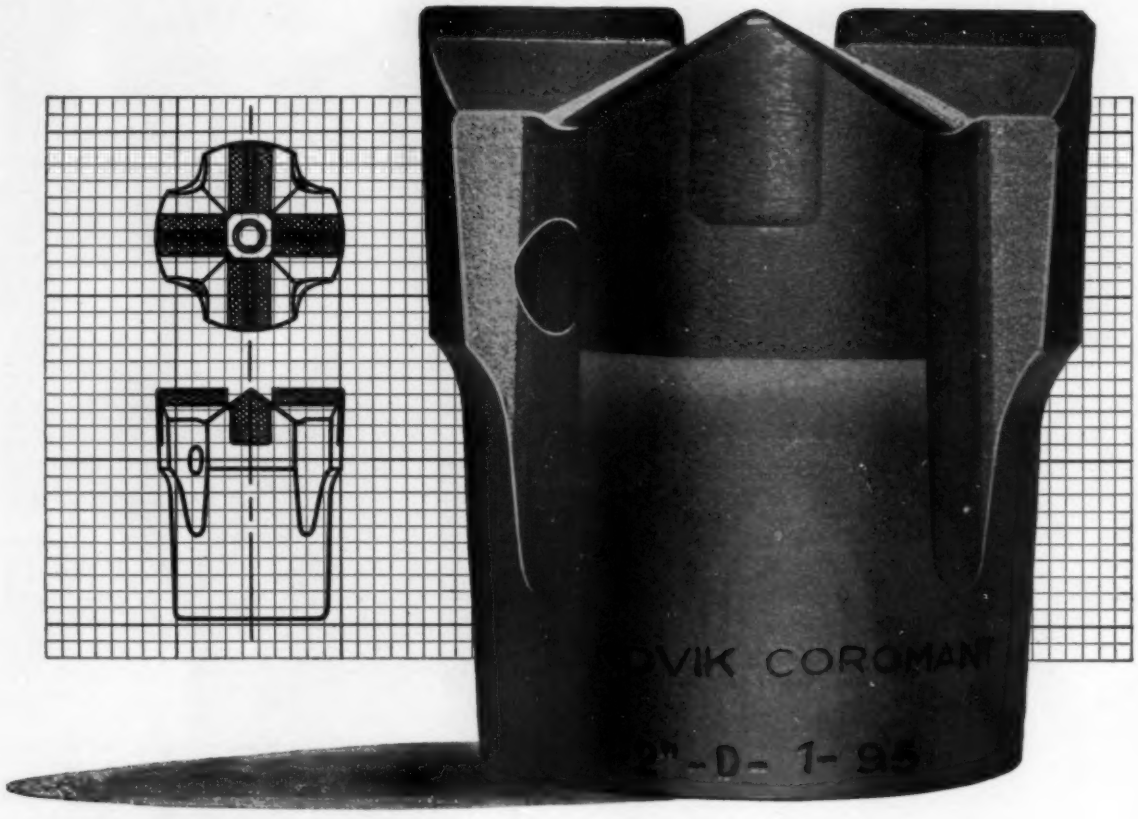
These exclusive features make Thor model MM-2 Drillcat the most productive rock-drill you can buy! Ask any Thor distributor for a Drillcat demonstration.

● Thor's super-powered 105M drifter rock drill. ● Rugged Thor BW-2 wagon drill mast and air control motor. ● Self-propelled with two 7½ h.p. Eimco air motors, power aplenty to haul itself and air supply. ● Rigid frame, proved in tractor design, no moving or wearing parts, long lasting, low maintenance. ● Aircraft-type accumulator in hydraulic system absorbs shock. ● Simple hand-operated track take-up. No tools required. No track locks required. ● Large flat platform. Ideal for operator when drilling toe holes, good for tool and fuel storage.

Thor
PORTABLE POWER
TOOLS

THOR POWER TOOL COMPANY
PRUDENTIAL PLAZA, CHICAGO
Branches in all principal cities

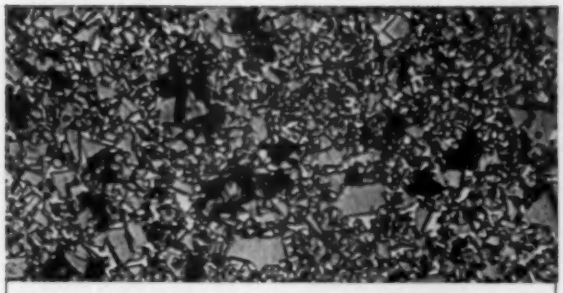
THIS ROCK BIT IS PRECISION-MADE FOR A HIGHER PERFORMANCE



Nothing tougher and more wear-resistant than the insert of a Sandvik Coromant 776 bit

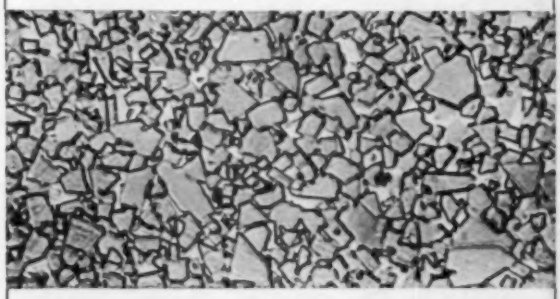
Rock bits that go on *and on* must have highest-grade tungsten-carbide inserts. Nothing but tungsten carbide in its purest state is good enough, will last as long. That's why the carbide that goes into a Sandvik Coromant 776 bit is meticulously controlled.

Sandvik, the world's largest manufacturers of brazed-in tungsten-carbide inserts for rock drilling, control every phase of production. Coromant carbide is scrutinized for impurities from the very first stages of processing the tungsten ore, right through to the final inserts. Add to that Sandvik's special process of securing the insert to the body, employing an exceptionally strong bonding metal, and you know why a Coromant 776 bit lasts longer. In 1955, one billion feet were drilled with these inserts, all fitted to Sandvik Coromant bits or integral steels. *Nothing is more conclusive of the quality of Coromant bits than this figure.*



LOW QUALITY TUNGSTEN CARBIDE

These are unretouched, 1200-times enlarged microphotos. Above, carbide full of impurities. Those black marks are contaminations which are present when production and quality control are deficient. Contamination of this kind weakens the carbide and reduces its working life.



SANDVIK COROMANT TUNGSTEN CARBIDE

This is Coromant carbide. Notice the uniformity of size and the even distribution of grain. Coromant inserts are free of dangerous porosity and impurities—the reason they go further, have greater strength.

Nothing stands the strain like the Swedish body of a Sandvik Coromant bit

When you put the strongest possible tungsten carbide into a rock bit, the body has to be the strongest available to take the extra strain. That's why Coromant bodies are made of high-quality Swedish alloy steel. But that's not all. Inserts and clearance are cylindrically-ground and the insert ends precision-tooled to exactly the same height. This means *smoother* drilling and *smoother* holes, because the load is equally distributed on all four inserts. *Precision engineering such as this give Coromant bits a longer life!*

Nothing fits like the precision-milled threads of a Sandvik Coromant bit

In order to get a smooth profile of the highest accuracy, Coromant threads are precision-milled in a special thread-milling machine and not made with a tap. Precision-milling too protects the skirt from common fatigue failures.

SANDVIK COROMANT 776 BITS

and Sandvik Coromant integral steels are available in standard sizes through Atlas Copco, who, in their own field, are the world's largest manufacturers of rock drills. Contact any of these offices *today* for further information and a demonstration.

U.S., Atlas Copco Pacific, Inc., 930 Brittan Avenue, San Carlos, California. Atlas Copco Eastern Inc., P.O. Box 2568, Paterson 25, N.J.
CANADA, Atlas Copco Canada Ltd., Montreal Airport, P.Q.
MEXICO, Atlas Copco Mexicana S.A., Apartado Postal 56, Torreon, Coahuila.

Atlas Copco

Manufacturers of Stationary and Portable Compressors, Rock-Drilling Equipment, Loaders, Pneumatic Tools and Paint-Spraying Equipment

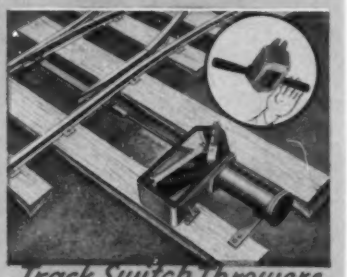
Half Century Rugged, Dependable profit-paying Equipment

A·M·D·CO

Canton Mine Door

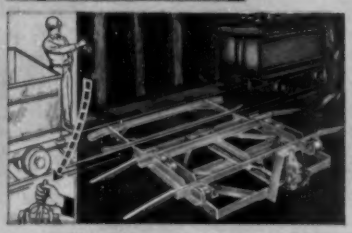
The Automatic Door operates mechanically by weight of car on activating levers. Air power operation may be had where desirable. Operates at any trip speed. Two doors provide air lock.

Install "Canton" American Mine Door Products in your Mine. Pay us out of increased profits.



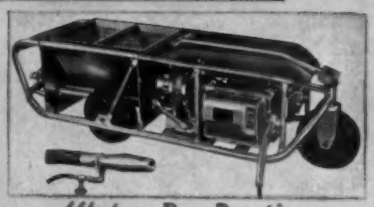
Track Switch Throwers

Electric or air operated. Route selections made by motorman at full trip speeds. Eliminates accident potential and extra man. Also ideal as Derailer.



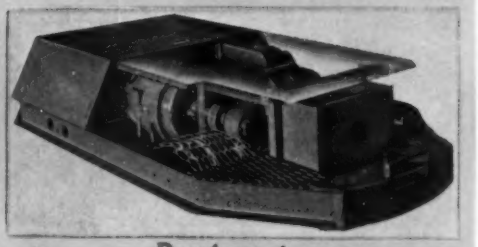
Canton Car Transfers

No alterations to track. Quickly installed and relocated—less rib to shoot than for jump switch—no hazards of cherry picker. Anti-friction bearings for easy hand operation. Manual or compressed air models available. (Air model illustrated.)



Wet or Dry Dusting

"Canton" Little Chief goes anywhere . . . rubber tire model 22½" high; skid model 18½" high for shuttle buggies, belts or mine cars; track-mounted for haulage roads. Delivers 34 to 60 lbs. dust per minute through 50 to 400 ft. 1¼" hose.

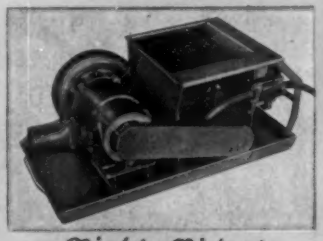


Dustmaster

The Track Mounted Hi-Pressure "Dustmaster" is the most powerful Duster ever built. Distributes dust to back areas 500 ft. from haulway.

Canton Track Cleaners

Hydraulic controls throughout clean entire track area mechanically in one pass—no costly hand labor; no dozers or loaders required. Now operating economically in coal, iron, copper, lead, potash, and salt mines.

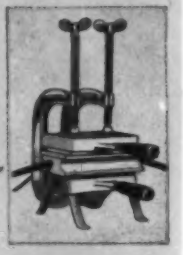


Mighty Midget

Weighs only 280 lbs. Easily moved on shuttle car. Hand cart available. Ideal for small mines . . . inexpensive . . . capacity 7 tons per shift.

Canton Cable Splicer

"Canton" Cable Splicers reduce down time in splicing cable. Machine men should carry a pocketful. Just pound around cable and go on working. No special tools.



Canton Vulcanizer

Restores insulation to original condition. Used with Canton Splicers, strong as original cable.

The American Mine Door Company

2073 Dueber Ave., Canton 6, Ohio

Write for complete brochures. Please use street and zone numbers.

the Sharples SUPER CLASSIFIER

Polyvinyl chloride . . . cement . . . barium sulphate . . . talc . . . sodium bicarbonate . . . ion exchange resins . . . zinc sulphide . . . iron oxide . . . flour . . . gypsum . . . uranium sandstone . . . fullers earth . . . these are but a few of the many dry powders which have been satisfactorily classified in the Sharples mill-size customer demonstration plant.

Now for the first time, there is available to industry a Super Classifier that provides ultra-sharp separations at high capacity, regardless of feed rate or size distribution in the feed—plus product recovery (yield) considerably higher than by any other means.

The Sharples customer demonstration plant is in all respects a full-scale commercial size classification plant capable of running continuously from 1,000 lbs. to 3,000 lbs. of product per hour. *Test results, therefore, are direct, require no extrapolation, and are precisely those obtainable from a Super Classifier of any capacity up to approx. 30,000 lbs. per hour.*

Sharples Bulletin 1280
will be sent upon request.

SHARPLES

THE SHARPLES CORPORATION
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NEW YORK • PITTSBURGH • CLEVELAND • DETROIT • CHICAGO • NEW ORLEANS • SEATTLE • LOS ANGELES • SAN FRANCISCO • HOUSTON
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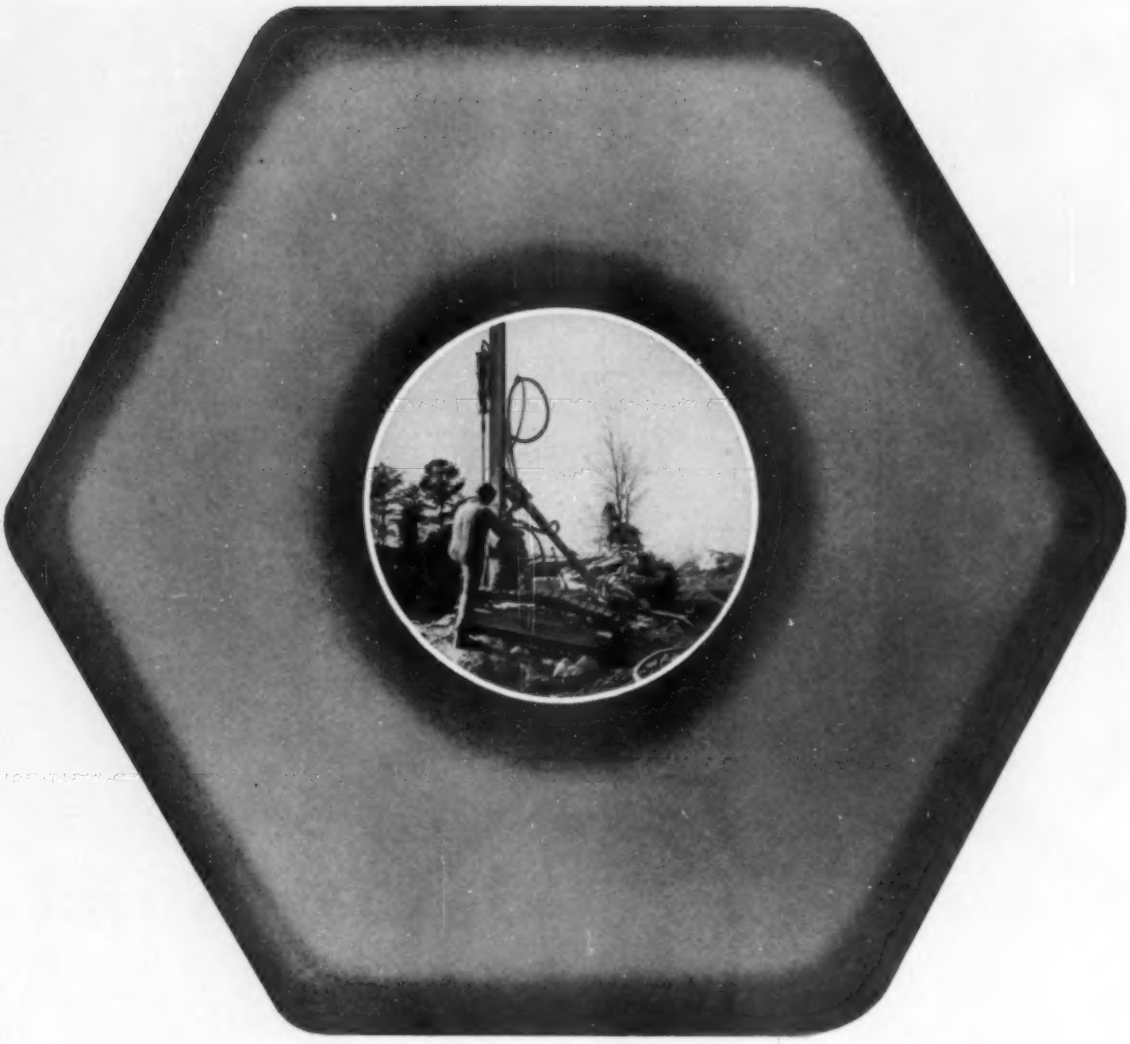


4320 Steel Solves the Problem of Carburized hollow drill rod

The Gardner Denver Co., Denver, Colo., felt that a carburized hollow drill rod would provide maximum resistance to wear combined with ability to stand up under impact and vibratory stress.

The problem was to find a steel that could be heat-treated in 20-foot lengths to develop these properties and which would maintain straightness within tolerance.

Gardner Denver found the answer in 4320 Ni-Cr-Mo Steel. As their chief metallurgist explained:

> "The alloy content of 4320 assures uniform hardening of both case and core to the values necessary for long life, and minimizes distortion."

The enlarged picture above shows an etched cross-section of a carburized 1¼" percussion drill rod. Notice the uniformity of the hardened case on both outer and inner surfaces.

One of the special combinations of properties available from nickel alloy steels may be the answer for your service or fabrication needs. No trouble to find out. Send details of your problem and we'll be happy to make a suggestion.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N.Y.

Copper Market Achieves Balance

Copper & Brass Research Assn. terms 1956 "a year of adjustment in copper." World supply and demand came into balance during the year as new copper was turned out by expanded operations at existing mines and by properties developed some three to five years earlier. Outlook is to 31 pct increased capacity by 1962.

Sulfur Reaches High in Both Supply and Demand

Output of sulfur from all sources increased in the past year to an estimated 7,875,000 long tons, or 825,000 tons more than in 1955, according to L. M. Williams, president, Freeport Sulphur Co. Consumption in the U. S. was estimated at 5.9 million tons.

Canada—New Iron Projects on the Doorstep . . . More Asbestos

If preliminary negotiations are carried through, a large Ontario taconite deposit will be developed by Iron Bay Mines Ltd., Toronto, through the Cleveland iron ore firm Oglebay-Norton Co. An estimated outlay of $35 million would be required. Site is 200 miles north of Port Arthur, Ont. . . .

Another iron development, about 300 miles northeast of Quebec City, will start this spring under Cartier Mining Co., Ltd., subsidiary of U. S. Steel Corp. High grade pellets will be turned out at the mine site as part of a $200 million project. . . .

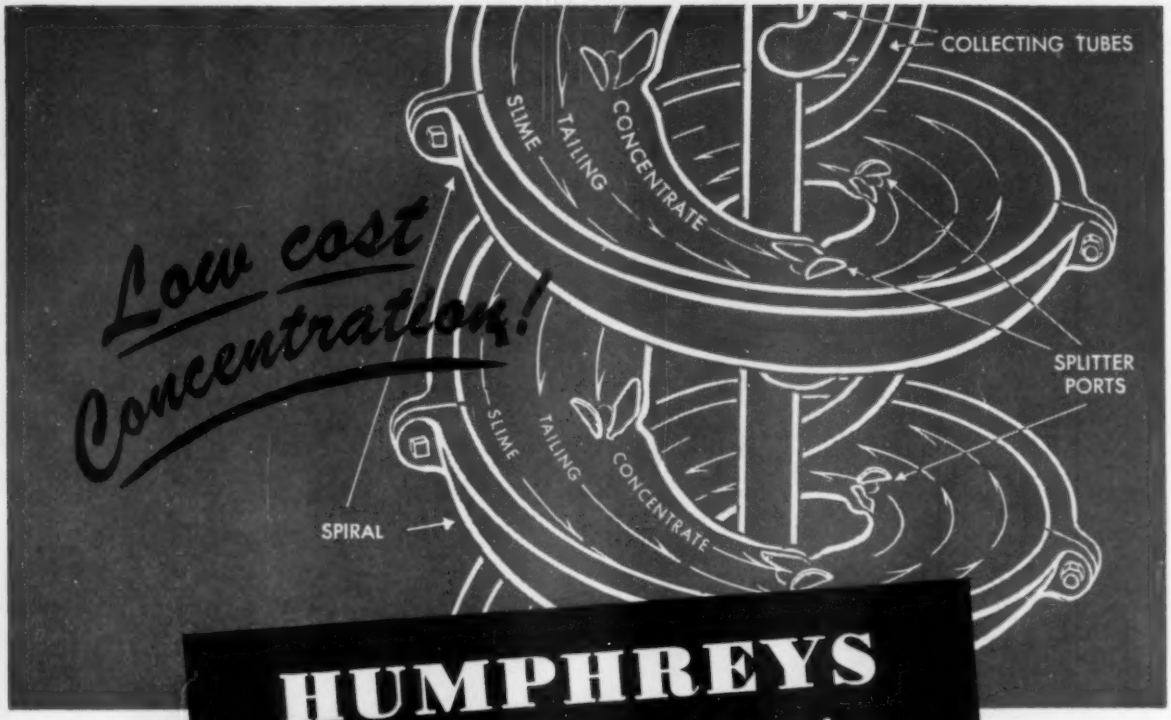
Exploration drilling in Newfoundland is reported to have blocked out 13.5 million tons of asbestos ore for Advocate Mines Ltd. The indicated find, near Baie Verte, occurs in a fiber-bearing peridotite. Indications point to a second large deposit near the present workings.

New Manganese Company Aims at Arc-Refined Rhodonite

U. S. Manganese Corp. has been awarded a contract from the General Services Administration to pilot a process for the commercial production of metallurgical grade manganese from rhodonite by the Sheer-Korman high intensity arc process (see *Trends*, April 1956). The new firm is a joint venture of Vitro Corp. of America, Sheer-Korman Assoc, Inc., and Great Divide Mining & Milling Corp.

Brazil's Manganese-Rich Amapa Now Shipping Ore

The Federal Territory of Amapa, Brazil, which boasts proven reserves of 11 million tons of 45 pct manganese ore, has started shipment of ore for export. Production from the region's mines may reach 700,000 tons per year, and Brazil would thus become the world's second biggest producer after India. Initial transport of ore was made possible with completion of a new Amazon port and a railroad. These facilities and mine development were achieved by the U. S.-Brazilian corporation, ICOMI, of which Bethlehem Steel Co. owns 49 pct.



Low cost Concentration!

HUMPHREYS
Spiral Concentrator

LOW COST CONCENTRATION

Humphreys
spiral concentrators
have economically recovered

Hematite	Biotite
Martite	Lepidolite
Magnetite	Vermiculite
Ilmenite	Native Copper
Rutile	Chromite
Zircon	Pyrite
Monazite	Barite
Phosphate	Tantalite
Wolframite	Columbite
Scheelite	Talc
Muscovite	Anthracite Coal

Throughout the world economy-minded mineral producers rely on Humphreys Spirals . . for low-cost concentration and increased production. These highly efficient concentrators are noted for economical installation, low-cost maintenance and dollar-saving operation . . . plus trouble-free performance over long periods of operation. No moving parts. Require very little floor space.

APPLICATIONS:

- Production of a concentrate and a tailing in a single rougher stage.
- Production of a bulk concentrate of several heavy minerals and a finished tailing.
- Scavenging the tailing from another process for the recovery of heavy minerals not amenable to the primary processes.
- Production of a finished concentrate, with a tailing to be treated by another process.

Write today for information on metallurgical tests of your ore samples for spiral treatment.

Engineering Division

THE HUMPHREYS INVESTMENT CO.

910 FIRST NATIONAL BANK BUILDING • DENVER 2, COLORADO

Sales and Manufacturing Agents—AUSTRALIA: John Carruthers & Co. Pty. Ltd. Edgecliff, N.S.W.—
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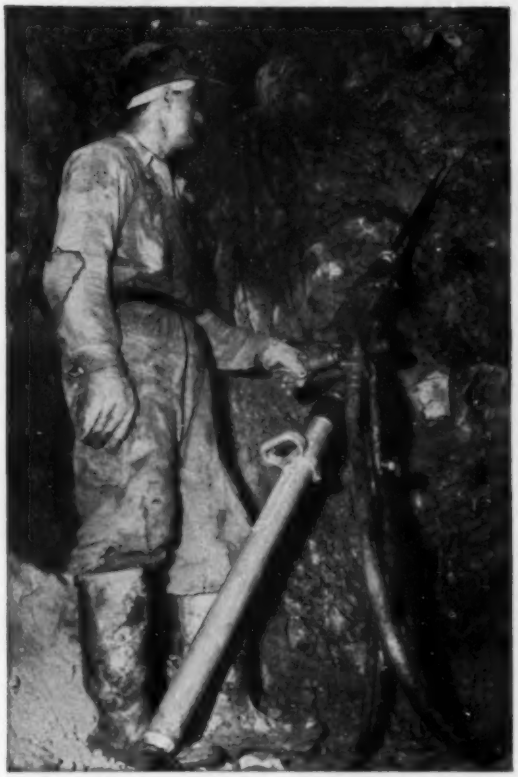
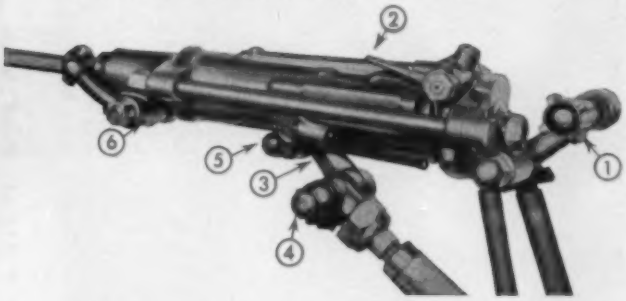
Ten Reasons Why the JR-38B

UNIVERSAL JACKDRILL



makes rock drilling a FASTER, EASIER one-man job

These Jackdrill features make the JR-38B the fastest-drilling, easiest-handling universal drilling unit ever developed



1. **Roll-Type Feed-Leg Valve,** built into handle, gives smoothly variable control from zero to full air pressure — can be reversed for right or left hand operation.
2. **Five Position Throttle** controls all functions — hole cleaning, shut-off, leg-feeding, hole collaring and drilling.
3. **Built-in Air Connection** between drill and feed leg eliminates third hose, simplifies setup and operation.
4. **Adjustable Tension** on hinge joint for easier handling.
5. **Adjustable Balance** shifts drill forward or backward to suit operator.
6. **Enclosed Steel Centralizer** has all working parts protected against dust and dirt.
7. **Constant Chuck Blowing** lubricates front end — keeps drill free of cuttings.
8. **One-Piece Chuck** with renewable recessed bushing — deflects air to side, protects operator against water splash.
9. **Rigid Construction** with fronthead recessed into deep counterbore. Built to stay on the job!
10. **Lighter Weight.** Telescopic feed leg weighs 10 lbs less than previous design. Much easier to handle.

CARSET JACKBIT IR

Longer-Lasting Carset Jackbits and the Faster-Drilling JR-38B JACKDRILL make an unbeatable drilling combination

THIS completely-integrated Jackleg Drill is designed to take full advantage of faster-drilling 1¾" Carset Jackbits — saves air consumption, saves powder, cuts bit and steel costs too. Use it as a drifter, a stoper or a Jackhamer. Ask your I-R representative for complete information or send for Bulletin No. 4144-A.

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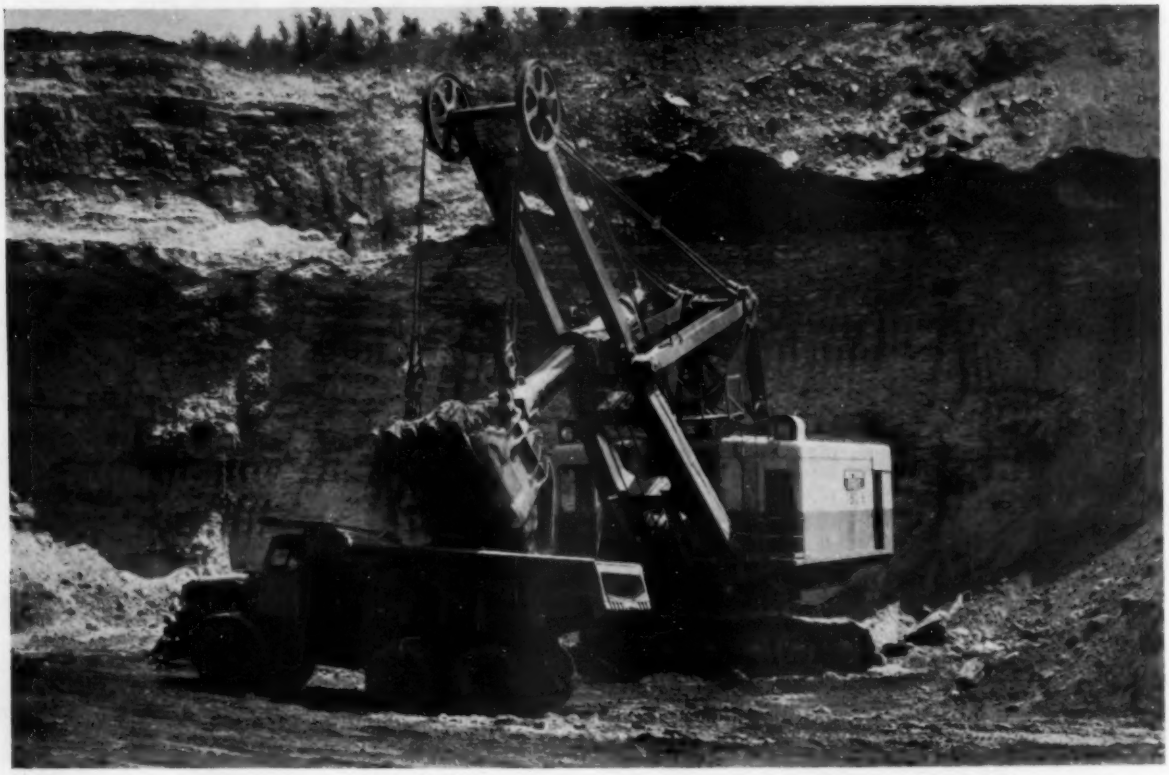
COMPRESSORS • TURBO-BLOWERS • ROCK DRILLS • AIR TOOLS • CENTRIFUGAL PUMPS • CONDENSERS • GAS AND DIESEL ENGINES

IN MINNESOTA . . . AND THE WORLD OVER

Profit Starts in the Pit

with Bucyrus-Erie Electric Shovels On the Job



On the Mesabi range, more ore is mined with Bucyrus-Erie Ward Leonard electric shovels than any other make. The 8-yd. Bucyrus-Erie 190-B, shown here, is loading for a large mining company — only one of a fleet of Bucyrus-Eries which they operate.

It is a combination of high-output, low cost performance that makes these shovels so popular with experienced mining men. Their modern front end design and heavy-duty construction offer great strength and durability while reducing power-wasting deadweight. Ward Leonard electric control permits rapid acceleration and deceleration for high-speed, high-output work cycles.

Cut costs where costs begin — right in the pits — and get a fast start on profits. Write direct to Bucyrus-Erie for complete details.

113156

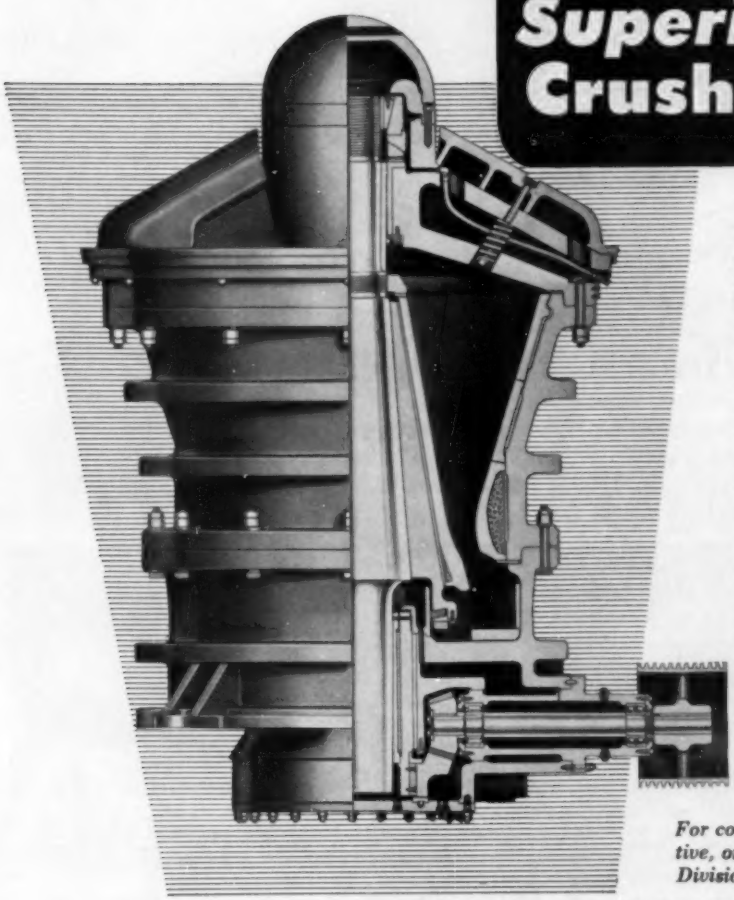
BUCYRUS-ERIE COMPANY

South Milwaukee, Wisconsin

Only one crusher gives you

Complete Adaptability for a BALANCED CIRCUIT

Superior Crusher



• With a *Superior* gyratory crusher pacing production, your entire circuit remains in balance. Subsequent equipment—crushers, screens, grinding mills — need not be readjusted to varied product sizes and capacities. The many variable factors provided by the *Superior* crusher permit obtaining the kind of production flow demanded by your other equipment. For example, changing eccentric throws, crusher speed or shape of crushing chamber varies capacity and product size. The *bottom discharge* permits utilizing the concrete foundation as a surge bin to control flow of material through your plant.

Hydroset control is another factor in maintaining a balanced circuit. Retaining the initial crusher setting by compensating for wear is a one-man, one-minute operation when a *Superior* gyratory crusher is so equipped. Emergency unloading is made easier with just the flick of a switch. A-4934

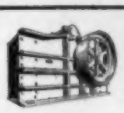
For complete information, see your A-C representative, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis., for Bulletin 07B7870.

Superior and *Hydroset* are Allis-Chalmers trademarks.

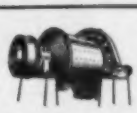
ALLIS-CHALMERS

Hammermills

Vibrating Screens


Jaw Crushers

Gyratory Crushers


Grinding Mills

Kilns, Coolers, Dryers

Put your haulage requirements in experienced hands...

...the **SURE** hands of experience which have specialized in the manufacture of heavy duty trucks for over 53 years. Model 35SL (shown above) carries 35 tons (24 cubic yards, struck). 400 HP Diesel with down-hill retarding hydraulic torque converter. DART-designed-and-built 50,000 lb. front axle and 110,000 lb. capacity drive axle and DART'S famous box girder frame give this truck superior strength.

Model 10SL. DART'S Jr. Workhorse. 10 ton capacity, powered by 150 H. P. diesel driving through a double reduction rear axle. Tires are 12:00 x 24 all around. Hydraulic steering and torque converter, optional.

Model 25SL. The famous DART standard dump truck. 300-335 H. P. diesel engine and hydraulic torque converter with built-in down-hill retarding. Hydraulic power steering. Known and used the world over.

Model 35T. Payload of 25 tons (24 cubic yards, struck). 335 to 400 HP and hydraulic torque converter with built-in down-hill retarding. Heavy-duty 4-speed transmission.

***POWER* for the Climb — *SPEED* for the Haul Road**

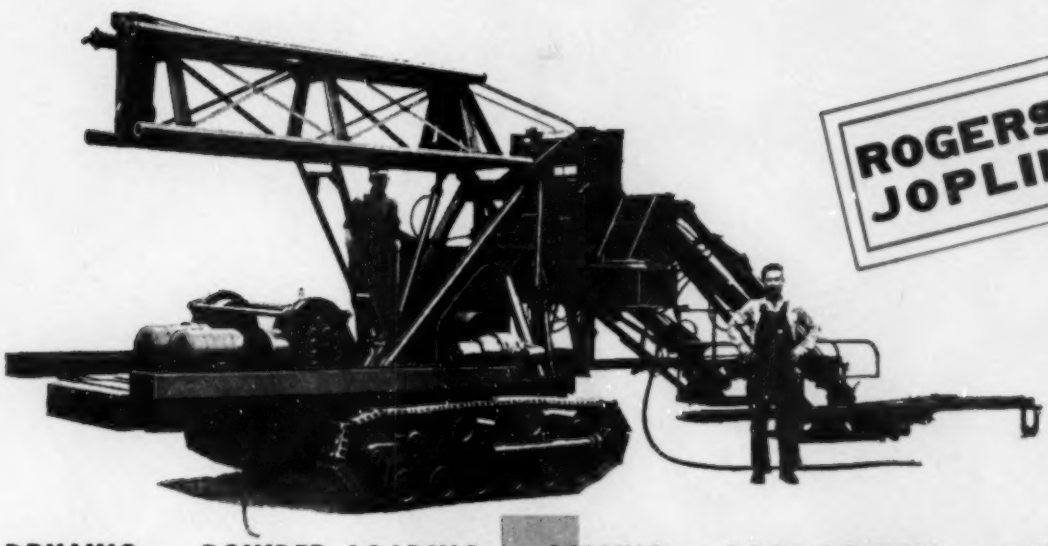
HEAVY DUTY TRUCKS EXCLUSIVELY SINCE 1903

DART TONNAGE ENGINEERED TRUCKS

Kansas City 8, Missouri

SUBSIDIARY OF THE CARLISLE CORPORATION

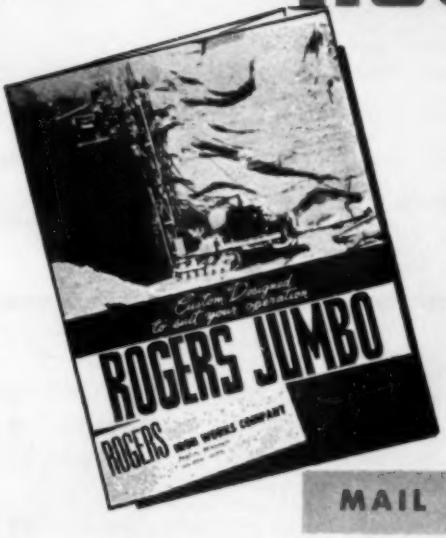
D-125



ROGERS JOPLIN

DRILLING • POWDER LOADING • SCALING • ROOF BOLTING • TIMBERING

ROGERS JUMBOS



ROGERS Jumbos were originally developed and proved in the underground zinc and lead mines of the Missouri-Kansas-Oklahoma district. The severe operating conditions, low cost mining, variety of underground operations and high production of these mines have demanded a jumbo of superior design, wide applicability and the utmost in reliability. Safety for the operator has been a carefully considered factor in design. For increased ECONOMY-PRODUCTION-SAFETY investigate the advantages offered by ROGERS for your operation.

MAIL THIS COUPON FOR BULLETIN 51-3

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- Drag Scrapers
- Underground Loaders
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- Dewatering Drags
- Rock and Ore Washers
- Portable Crushing Plants

ROGERS IRON WORKS COMPANY
JOPLIN, MISSOURI

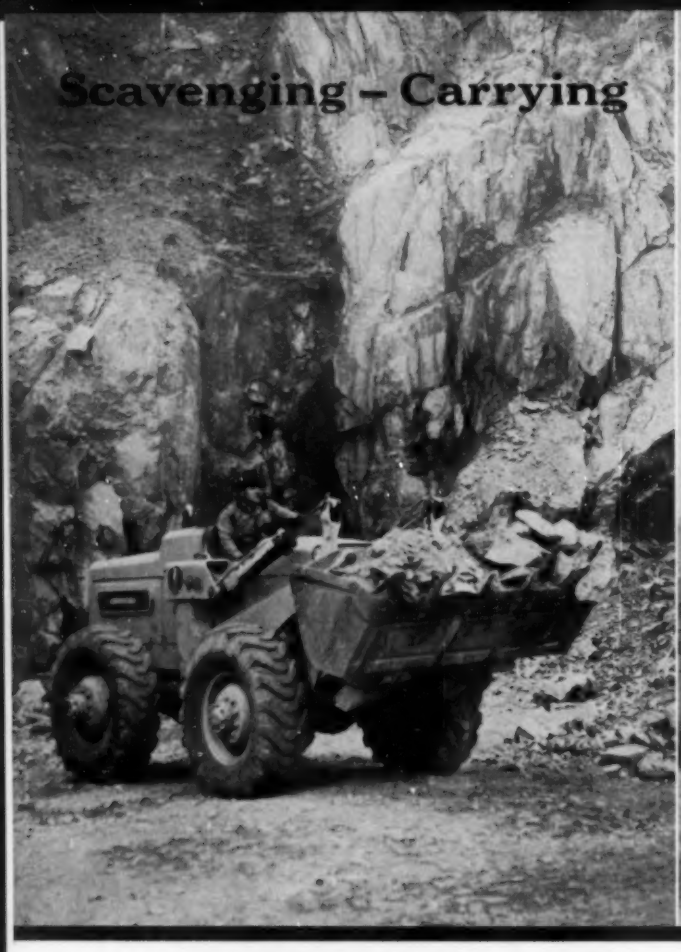
Yes . . . please send me your bulletin on Jumbos

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____



More Uses — More

Versatility and mobility — the ability to do *many* jobs and the ability to get *to* any job quickly and easily — are big reasons for the success and acceptance of rubber-tired tractor-shovels at pits and plants. Cleaner operations are also an important factor in favor of this rubber-tired equipment, as it doesn't chew up the ground and travel surfaces or raise dust like crawler tracks. And among rubber-tired tractor-shovels, none can match the versatility, mobility and productive capacity of the three new 4-wheel-drive "PAYLOADER" models, size for size. Operators of both underground and open pit mines, as well as processors and smelters, praise their effectiveness for loading cars and trucks . . . charging hoppers . . . feeding conveyors, handling tailings . . . clean-up around power shovels . . . maintaining haul roads . . . stockpiling . . . spotting railroad cars and general drawbar work. They like the more reliable traction . . . easier, faster and safer operation . . . increased digging power . . . greater carrying capacity . . . and other outstanding improvements found in these new models.

Your "PAYLOADER" Distributor wants you to prove on your own work that these new "PAYLOADER" units are the most useful, productive and profitable tractor-shovels you can own.

Output — More Profit

Full of "More-Yardage" Features

Exclusive power-transfer differentials provide sure-footed traction on mud, gravel, ice and snow.

Hydraulic load-shock absorber cushions the loaded bucket, smooths the ride — permits higher carry speeds with less spillage.

No-stop power-shift transmissions can make ALL shifts on-the-go, under full engine speed. No stopping for RANGE SHIFTS . . . no "clutching".

Powerful 40° bucket pry-out, break-out action — Rugged planetary final drives — Power steering — 4-wheel power brakes.

Owners expect more from a "PAYLOADER" and they get more, because more of them are in service than all other makes combined. They're designed right and built right . . . they're sold and serviced right by a nearby "PAYLOADER" Distributor.

PAYLOADER®
MANUFACTURED BY
THE FRANK G. HOUGH CO. LIBERTYVILLE, ILL.
SUBSIDIARY—INTERNATIONAL HARVESTER COMPANY

THE FRANK G. HOUGH CO.
916 Sunnyside Ave., Libertyville, Ill.

Send data on 4-wheel-drive "PAYLOADER" tractor-shovels as checked

- ☐ HO (2¼ yd. payload, 1¾ yd. struck)
- ☐ HH (1¾ yd. payload, 1⅓ yd. struck)
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38

INDUSTRIAL SCREENS

for accurate, low-cost screening

You can get a CF&I Industrial Screen that has exactly the right combination of features to assure fast, accurate, low-cost service in your screening operation. That's because CF&I Screens are available in standard and special weaves . . . and can be supplied in a wide variety of carbon and alloy steels, as well as in non-ferrous metals.

It's extremely simple to get the complete story on how CF&I Industrial Screens can be used to improve your screening operation—just contact your nearby CF&I representative. No obligation on your part, of course.

SPACE SCREENS

THE COLORADO FUEL AND IRON CORPORATION

3676

THE COLORADO FUEL AND IRON CORPORATION: Albuquerque • Amarillo • Billings • Boise • Butte • Casper • Denver • El Paso • Ft. Worth • Houston
Lincoln • Los Angeles • Oakland • Oklahoma City • Phoenix • Portland • Pueblo • Salt Lake City • San Antonio • San Francisco • Seattle • Spokane • Wichita
WICKWIRE SPENCER STEEL DIVISION: Atlanta • Boston • Buffalo • Chicago • Detroit • New Orleans • New York • Philadelphia
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CYANAMID

REAGENT NEWS

"ore-dressing ideas you can use"

FROTHER PROBLEM?

Why not try AEROFROTH® 65 Frother?

This synthetic water-soluble frother is finding wide acceptance throughout the world as a replacement for conventional pine oil, cresylic acid and alcohol frothers.

AEROFROTH 65 Frother is a non-promoting frother that is usually fed as a water solution thereby allowing very accurate control of feed rates. It is very effective at dosages only ⅓ to ¼ as large as with conventional frothers. It works very well in high lime circuits as well as in neutral or slightly acid circuits.

Typical reports from Cyanamid field engineers on the use of this product are:

> *"Copper property treating 220 tpd formerly used 0.5 lb. cresylic acid per ton. Replacement of cresylic with only 0.014 lb. AEROFROTH 65 Frother per ton resulted in substantial reduction in frother costs with same metallurgy.*
>
> *"Mexican gold-copper operation treating 550 metric tons per day had been using methylamyl alcohol at rate of 0.5 lb. per ton. Phenomenal reduction in frother consumption occurred with the use of only 0.005 lb. per ton of AEROFROTH 65 Frother. Furthermore, gold recovery in copper concentrate (desirable at this operation) was increased by over 5%."*

A note to our nearest office or field engineer will bring you a sample of AEROFROTH 65 Frother.

AMERICAN CYANAMID COMPANY

MINERAL DRESSING DEPARTMENT

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Amsco Alloy Ball and Rod Mill Liners

For longer mill life specify AMSCO®
BALL AND ROD MILL LINERS

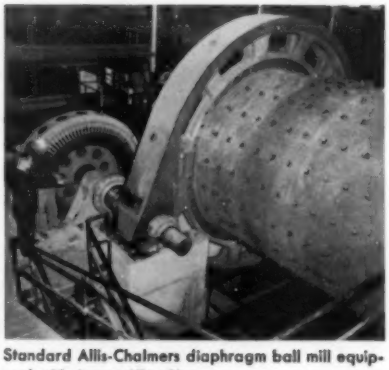
Processing iron ore, copper ore and cement mill clinkers gives a real workout to ball or rod mill parts

For top grinding efficiency, liners of numerous designs found in many leading makes of ball and rod mills are cast from special Amsco Alloy steels. These wear-tough steels are specially engineered to give the highest resistance to wear from abrasion and impact.

Amsco engineers and metallurgists have long co-operated with the manufacturers of ball and rod mill equipment to provide the right wear-resistant liner alloys and the advanced design features that will insure top mill performance.

If you have a problem with fast-wearing and costly mill liners, Amsco can recommend the right solution for you...in either special alloys or manganese steel.

Why not contact your ball or rod mill manufacturer's representative today and inquire about longer wearing Amsco Ball or Rod Mill Liners?



Standard Allis-Chalmers diaphragm ball mill equipped with Amsco Alloy Liners.

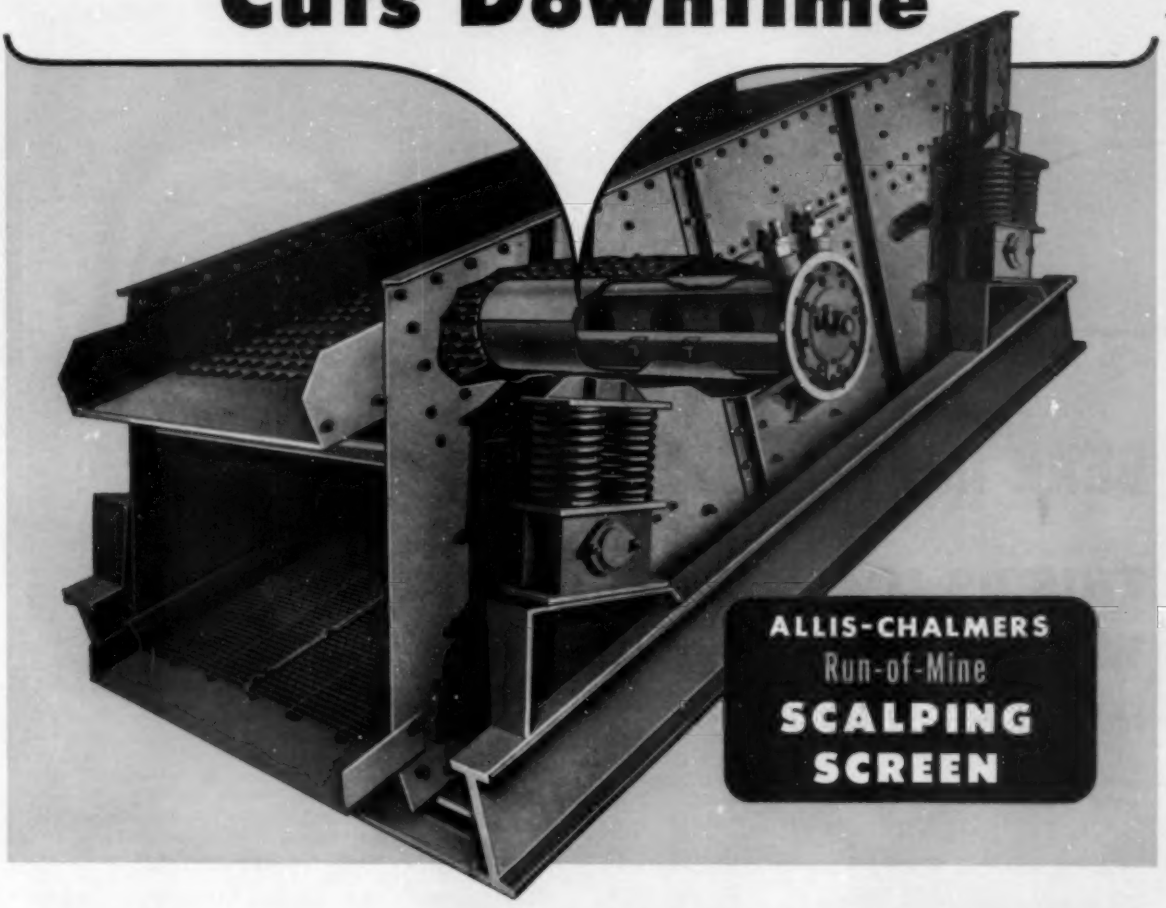
AMERICAN Brake Shoe COMPANY

AMSCO

American Manganese Steel Division • Chicago Heights, Ill.

OTHER PLANTS IN: DENVER, LOS ANGELES, NEW CASTLE, DEL., OAKLAND, CAL., ST. LOUIS; JOLIETTE, QUEBEC

Replaceable Cartridge Mechanism Cuts Downtime



CHANGING this screen mechanism is as simple as changing a battery in your car. All you do is remove four bolts and slide out the entire mechanism.

The cartridge mechanism gives you the added advantage of taking it to your maintenance bay or shop where all facilities are handy and maintenance costs are lowest.

If your process involves a multiple installation, it is highly profitable to keep a replacement mechanism in reserve. Slip one out, slide another in. Keeping production flowing is as easy as that.

Other Maintenance-Reducing Features

The proven simplicity and record-low maintenance of two-bearing design . . . largest, most sturdy bearings ever installed on a vibrating screen . . . multiple (two sets per corner) steel support springs that prevent transfer of vibration to structure even when materials stick to screen . . . sealed-in mechanism with single grease seal on drive side that eliminates multiple possibilities of dirt infiltration — all these features keep maintenance cost low.

For complete information, see your nearby Allis-Chalmers representative or write for Bulletin 07B8368. Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

A-5194

ALLIS-CHALMERS

BEAR IN THE BORROW PIT

THIS D9 LOADS SCRAPERS WITH 25 HEAPED YARDS IN 45 SECONDS

Phil Dudenhoefer, grade superintendent, knows from production charts that the D9 pusher loads more yards faster, at lower cost.

Working near Eau Claire, Wis., on a highway relocation job, L. G. Arnold, Inc., cut cycle times and boosted yardage with a Caterpillar D9 Tractor push-loading a CAT* DW21 and No. 470 Lowbowl Scraper.

On a round-trip haul of 3 miles they averaged 100 cu. yd. per hour—4 heaped loads of 25 cu. yd. each. Loading time on overburden, with the mighty D9 pushing, was an average of only 45 seconds.

Phil Dudenhoefer, grade superintendent for L. G. Arnold, Inc., says, "I've got both feet right in the dirt, where I record output and performance of every machine. With the D9 as pusher, the DW21-No. 470 unit is outproducing by far any other equipment on the job."

That experience has been shared by hundreds of owners, as more and more D9 Tractors have gone to work in borrow pits or on stripping operations. For fast loading you simply can't beat the D9, with its 320 HP at the flywheel and maximum drawbar pull of 98,000 pounds. Power-boosted controls and excellent visibility make this giant one of the easiest of all tractors to operate. It's available either with torque converter or direct drive with oil clutch. Maintenance is easy, too. And it's ruggedly built to lick the world's toughest jobs.

Your Caterpillar Dealer can show you actual performance records of higher production at lower cost per yard. He'll give you a demonstration right on the job. And he stands behind the long life of every machine with reliable service and parts you can trust.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

HEAVY-DUTY EARTHMOVERS FOR THE HARD WORK

Comstock Iron Ore

Moved Via Push Button

MINING engineering NEWS

Iron ore is stockpiled at the rate of 1000 tph. Two storage belt conveyors and traveling belt conveyor stackers stockpile ore by grade as it is received from the mine. On reclaiming, high grade can be blended with low grade to meet blast furnace needs.

Colorado Fuel & Iron Corp.'s Comstock mine at Iron Mountain, Utah employs a highly flexible system of belt conveyors for stockpiling and blending its varied grades of iron ore.

Ore is first stripped from an open pit, shovel-loaded into 34-ton rear-dump trucks, and delivered to a crushing plant. Here the ore is scalped, crushed, stockpiled and later blended, sized, and loaded into railroad cars for shipment to the CF&I steel mill at Pueblo, Colo.

Ore to be stockpiled is stacked by grade into two long storage piles by parallel belt conveyors and traveling stackers. Storage is controlled by one man stationed at the top of the screening tower. There push buttons activate seven belt conveyors, a vibrating screen, two traveling stackers, and a number of gates and chutes.

From the crusher, ore comes via belt to the screening tower where it can be directed to a shuttle conveyor, a vibrating screen, or to a conveyor leading to the car loading pocket. The shuttle can discharge onto either of two belts which carry ore to the traveling stackers.

The stackers are track-mounted and self-propelled. They can be positioned at any point along 250 ft of the storage pile and they travel at 50 fpm.

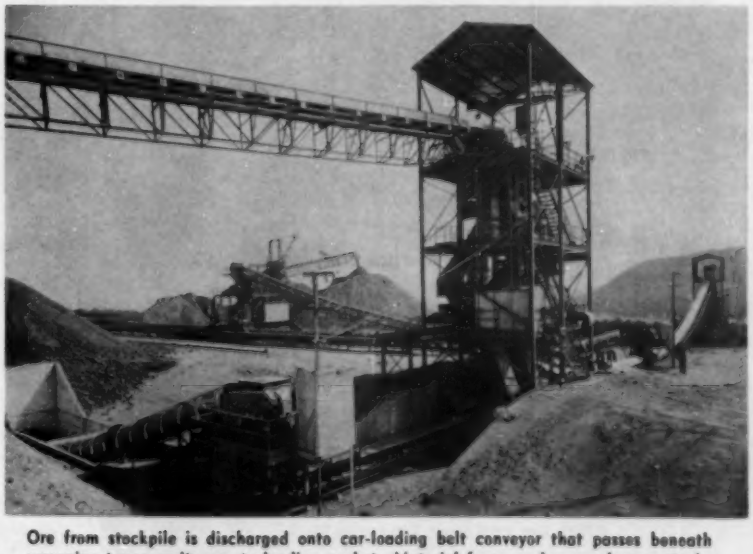
When ore is to be sized before storage, it is directed to the vibrating screen which sizes to three classifications. Any two sizes can be separately stockpiled and the third delivered directly to the car loader.

A flow selector switch permits distribution of various grades of ore to storage conveyors and car loading conveyors in a variety of combinations.

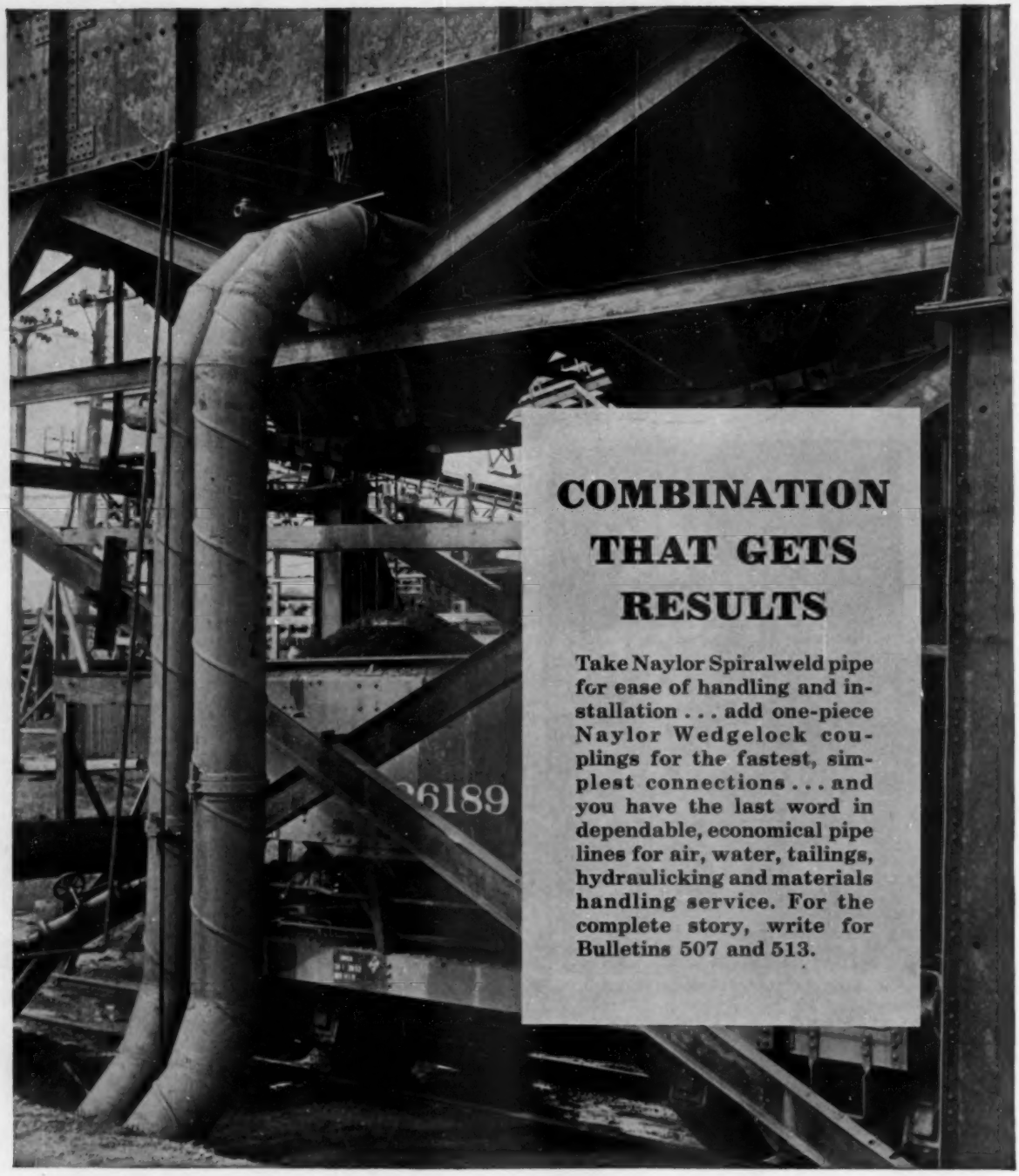
When ore is to be reclaimed from storage it is withdrawn through two tunnels beneath the piles. Two traveling variable speed feeders draw ore from any of 11 gates in each tunnel and conveyors carry it to the loading pocket for shipment. It is thus possible to mix four grades of ore, from four parts of the two storage piles, in proportions to meet blast furnace demand.

A single feeder can operate at 1500 tph. If two or more feeders are used, speed and capacity are reduced.

At the loading pocket —¾-in. ore passes through a vibrating screen into one bin and oversize flows over into a second bin. The two bins are positioned over two railroad tracks, so that two cars can be loaded at the same time with both sizes of ore.



Ore from stockpile is discharged onto car-loading belt conveyor that passes beneath screening tower on its way to loading pocket. Material from crusher can bypass stockpile and load directly onto car loading conveyor through chutes in transfer house.



COMBINATION THAT GETS RESULTS

Take Naylor Spiralweld pipe for ease of handling and installation . . . add one-piece Naylor Wedgelock couplings for the fastest, simplest connections . . . and you have the last word in dependable, economical pipe lines for air, water, tailings, hydraulicking and materials handling service. For the complete story, write for Bulletins 507 and 513.

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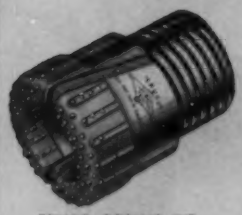
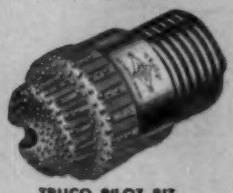


TRUCO CORING BIT

TRUCO CONCAVE BLAST HOLE BIT

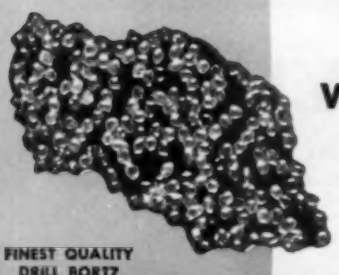


TRUCO PILOT BIT

TRUCO IMPREGNATED CORING BIT

TRUCO REAMING SHELLS

TRUCO STANDARD OIL FIELD BIT



FINEST QUALITY DRILL BORTZ

DRILLING COSTS HIGH? *Read this—*

Cost per ton for drilling
DOWN 66%

Cost per foot drilled
DOWN 37.7%

Carats used
DOWN 22.4%

Footage per bit
UP 54%

27,560 FEET WERE DRILLED *by this Truco bit before it was retired from service for study*

Random purchase of diamond bits proved extremely costly in the early days of long blast hole drilling in limestone at The Warner Company's Bell Mine, Bellefonte, Pa. So, tests were conducted to provide data for bit performance analysis.

The analysis showed that the pilot type, non-coring bit delivered highest footage, highest diamond salvage and lowest cost per foot drilled. It also indicated the advantages of working with *one* manufacturer in developing a bit tailor-made to the job. The Truco bit was adopted and developed through progressive stages of improvement to the present level of performance which is remarkable by any standards.

One Truco bit had drilled 27,560 feet of hole when it was taken out of service to be studied. That footage is exceptional but footages of 10,000 to 12,000 feet per bit are not uncommon.

These studies have been continuous and cover type of bit, carats per bit, diamonds per carat, carats used per bit, salvage per bit, footage drilled per bit, bit cost, cost per foot drilled and cost per ton. They are, therefore, complete and factual and the information they yield has paid off. If you'd like to have a more detailed report of these studies, we'll be glad to send you a copy.

And, if drilling costs are your responsibility, maybe you should talk to the Truco Diamond Drill Bit man. Very likely he can help you.

Year	Footage Per Bit	Carats Used Per Foot Drilled	Salvage	Cost Per Foot Drilled	Cost Per Ton
1st	3630	.00089	67.7	0.0122	.0065
2nd	4930	.00085	68.1	0.0111	.0041
3rd	4300	.00084	69.6	0.0110	.0032
4th	5590	.00069	67.7	0.0076	.0022
	UP 54%	DOWN 22.4%		DOWN 37.7%	DOWN 66%

TRUCO DIAMOND BITS

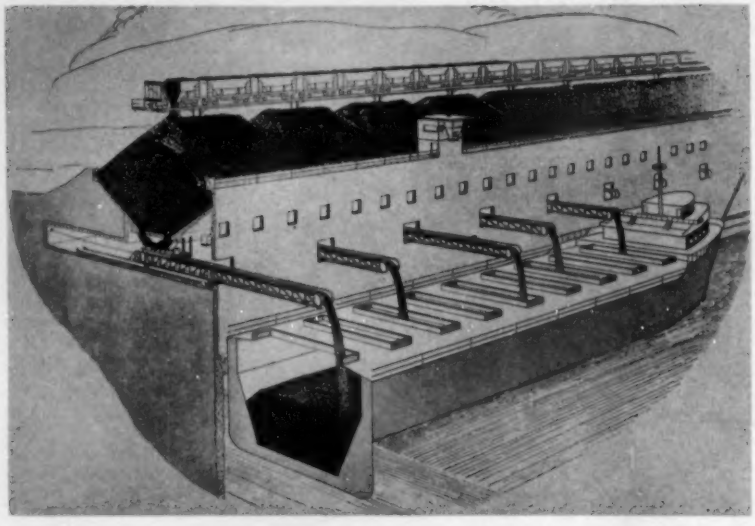
by

WHEEL TRUEING TOOL COMPANY

3200 W. Davison Avenue, Detroit 38, Michigan

WHEEL TRUEING TOOL CO. OF CANADA, LTD.
575 Langlois Avenue, Windsor, Ont., Canada

Conveyor Belt Vessel Loader



A new system of 25 shuttle belt conveyors is planned for loading taconite pellets at Erie Mining Co.'s Taconite Harbor, Minn. when this Lake Superior port facility begins operation. Belt conveyor system, designed and built by Link-Belt Co., permits loading as many as ten alternate hatches at one time—a departure from the conventional method of loading ore vessels by chutes.

Two vessels can be loaded simultaneously and the complete system of shuttle belts for each vessel is operated from a central control tower. Pellets arrive at the dock in rail cars, are emptied into a storage bin and weighed as they are loaded into hatches. Each conveyor on the 1200-ft-long dock is capable of loading taconite pellets at the rate of 750 or 1500 LT per hr.

Another Offshore Drilling Platform

A $3¼-million portable offshore platform was recently completed by R. G. LeTourneau Inc. Constructed at Vicksburg, Miss., the platform, which weighs 8 million lb in operating trim, will be used for oil exploration in the Gulf of Mexico by Zapata Offshore Co.

In operation it can lower its 145-ft legs to the bottom and, within a 2-hr period, will have elevated its

deck to the height of a 10-story building above the ocean floor. Triangular platform has three legs which are driven by electric gear-motors. Note the helicopter landing area, surrounded by safety net, on top of far leg.

Smelting on Site

with

MACE Furnaces

and

Sintering Hearths

Saves high transportation and treatment charges on your ores and concentrates.

Wire or write for new catalog.

Standard sizes 5 to 250 tons capacity. Working scale tests on ton lots or larger made at our Denver smelter. Send us an analysis for preliminary report.

The Mace Company

FIRE CONCENTRATION METALLURGISTS

2759 Blake Street, Denver 5, Colo., U.S.A.

NEW, SAFE and AUTOMATIC

Mayo Mine Car Coupler

. . . the coupler with the mating instinct

Mayo's new, cast steel coupler for narrow gauge mine cars couples instantly on tangent or curves. Safe, self-centering link completely eliminates all hazards of hand coupling. Only a little more expensive than link-and-pin, it more than pays for itself by preventing accidents. If you can save one smashed finger, you've got these couplers paid for. Easily installed by bolting to existing cars. Write for Bulletin No. 21.

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Steel Forms
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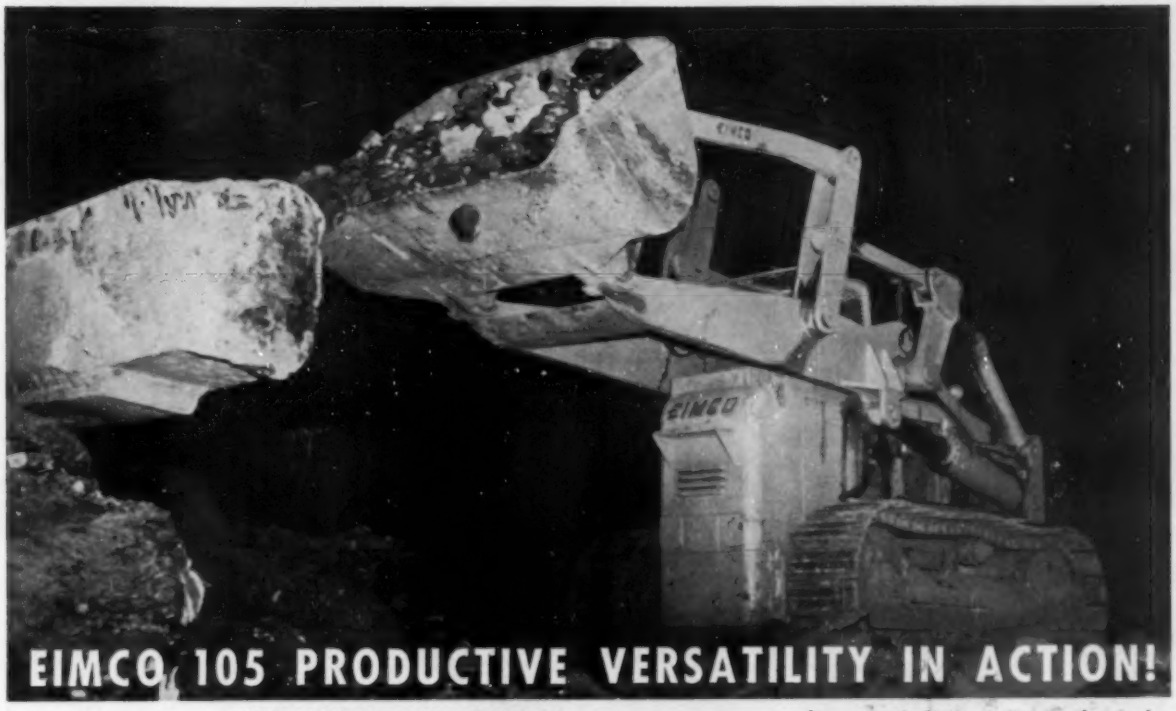

EIMCO 105 PRODUCTIVE VERSATILITY IN ACTION!

NEW! FRONT END LOADER

Here's the latest addition to the 105 wide-range family of rugged earth-moving tools.

In loading applications where physical and haulage conditions make its use more practical . . . here is a front end loading mechanism that gives you extra strength for the most severe job.

Large, double-acting hydraulic boom cylinders provide ample power to hoist loads weighing up to 15,000 lbs. to full height. Boom and bucket controls may be operated simultaneously.

To fill the big (2½ yard) bucket, this loader develops 25,000 lbs. digging force at the lip. 40,000 lb. pry-out force and 40 degree bucket tip-back at ground level gets full bucket loads, minimizes spillage. It carries loads close and low for maximum stability.

It operates in 9' 6" headroom . . . discharges into haulage units up to 14'.

Exclusive features of the hydraulic system provide an extra margin of protection against mechanical delays.

Bulldozer

Dozer blade attachments are designed to make full use of the extra-production features of the 105. In broad usages such as cutting haul roads for logging outfits . . . pioneering in shale and hard rock . . . clearing fire paths for the Forest Service . . . the Eimco 105 Bulldozer has proven its high-capacity ability the world over.

All attachments are Eimco-built to standard SAE mounting dimensions for the basic 105 Tractor. This means extra performance from every attachment through independent track maneuverability . . . up front visibility . . . power shift operating ease . . . balanced design for maximum stability . . . quality built for dependable on-the-job service.

Excavating Loader

Where digging is extra tough . . . and haulage provisions can be adopted to take full advantage of overhead discharge — the time-proven 105 Excavating-Loader will give you **bonus** loading power at the bucket lip and **bonus** dumping speed to accelerate the entire cycle.

Unique contour of the rugged rocker arms . . . bucket design and smooth, steady flow of engine power transmitted to the bucket lip through the torque converter gets 39,200 lbs. of digging force right where you want it . . . in the pile. Awkward maneuvering to get into dumping position is eliminated in ideal overhead discharge applications.

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

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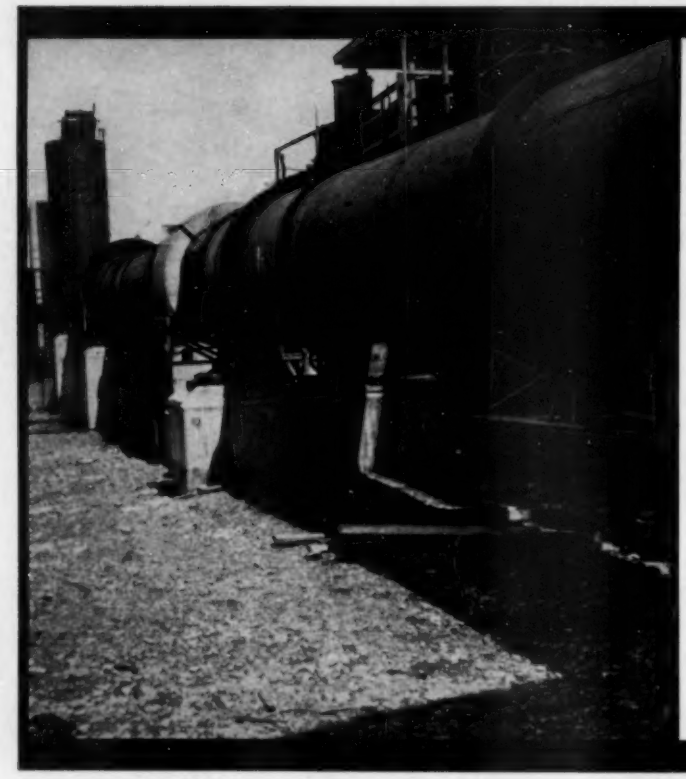
B-339

The Bowling Champ
buys a custom-made ball
because he gets
something **EXTRA**



the profit-wise operator

BUYS TRAYLOR ROTARY KILNS

for the same reason

Chances are Traylor has already Traylor-made a Rotary Kiln quite similar to the one best suited for the most efficient, profitable thermo-processing of your particular product. Sizes have been built from the smallest up to 12′ in diameter and 450′ in length. Bulletin No. 11–121 will give you complete details and specifications, write for your copy today.

TRAYLOR ENGINEERING & MFG. CO.
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the experts agree . . . there's nothing like

TRAYLOR-MADE

equipment for peak performance

A Traylor leads to greater profits

MINERS USE EIMCOS WHERE PROFIT DEPENDS ON HIGH PRODUCTION

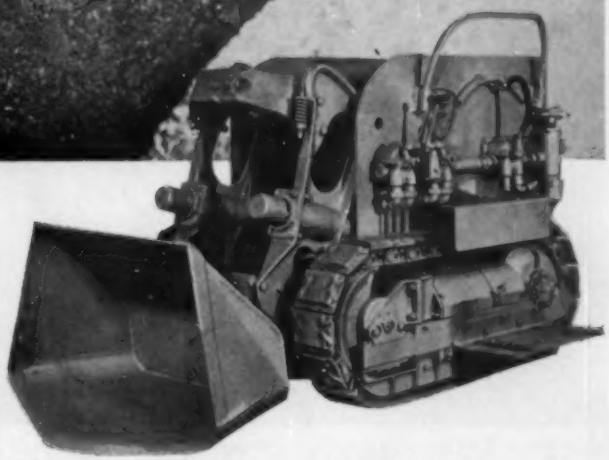
At exploration projects . . . and mucking low-grade ore where profit is realized only when high tonnage quotas are met — the Eimco 630 Crawler-Excavator is expanding production opportunities.

Increased demand for the versatile 630 by firms who previously were stymied in exploration and development projects because of tonnage requirements . . . is proof that Eimcos are helping to solve this production problem.

The 630 also is helping to recover large, low-grade ore bodies through exploration of deeper horizons. Areas that other underground development hasn't touched during years of continuous mining activity, are now worked profitably.

One important phase of these expansions is tough shaft sinking jobs. Often, occurrence of water adds to the already severe service conditions under which equipment must perform.

But as one superintendent put it, "We haven't had trouble digging the last feet of any wet shaft round with the Eimco and it really takes punishment."



Working in a 26 foot diameter shaft with mine-rail concrete lining . . . this Eimco 630 Crawler-Excavator is saving labor and maintenance costs while providing high tonnage production. Independent track maneuverability, operating ease and powerful, fast digging-loading ability makes the Eimco ideal for this application.

This is possible because the 6,000 lb. digging effort at the bucket lip gives the 630 tremendous crowding and digging power . . . enough to fill the big, half-yard bucket in any muck pile. And rugged construction with all vital parts protected against moisture and foreign material — insures long, on-the-job service.

In any underground excavating job . . . the standard Eimco 630 will permit you to increase your earning potential without addition of specialized machinery. Write today for full information!

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

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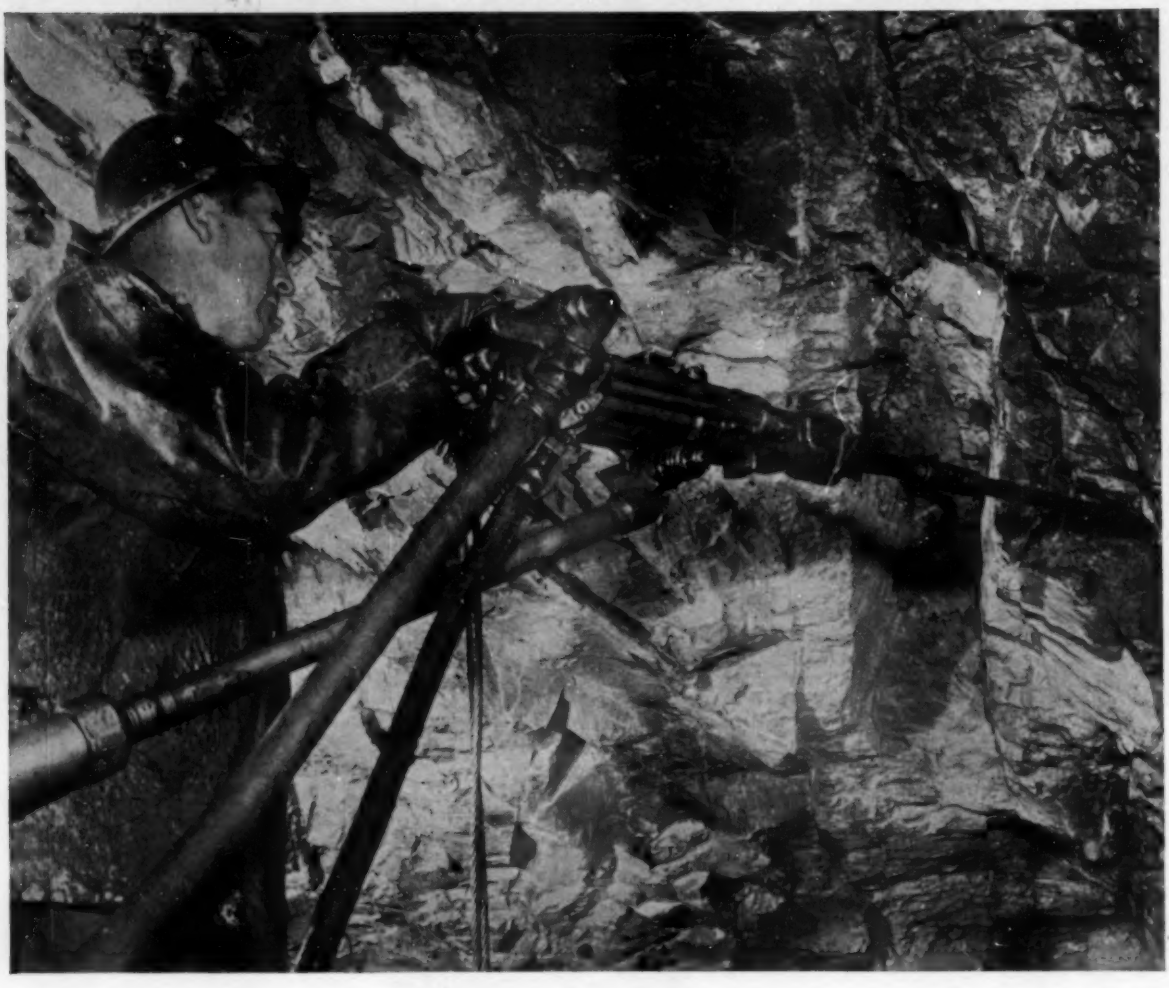
B-360

Gardner-Denver . . . Serving the World's Basic Industries



Lightweight powerhouse for low-cost drilling

Here's the lightweight drilling combination that's easily carried into far corners of the mine—enables one man to run in a remarkable footage record during the shift. Consists of the lightweight FL-48 or FL-58 Sinker mounted on air feed leg with feed travel of 24″, 36″, 48″ or 60″.

Lightweight Gardner-Denver drills have the proper combination of characteristics for fast drilling with tungsten carbide bits. May be equipped with Gardner-Denver air-operated water gland—throttle-controlled—that automatically provides water-on, air-on, air-off, water-off cycle.

Feed legs available with weight-saving aluminum feed cylinder. Push-button bleed for fast retraction. Single air hose supplies both drill and feed leg, and all controls are on the drill back-head.

Send for full details.

GARDNER - DENVER

THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Capacity Was A Problem . . .

UNTIL THIS FIRM INSTALLED AN EIMCO AGIDISC FILTER

Installation of an Eimco Agidisc Filter was made by a large nickel producing firm after a competitive-make of disc-type filter could not handle a nickel ammonia leach residue at the required production level.

Replacement of the 8′ 6″ × 10 disc filter with an 8′ 10″ × 10 disc Eimco Agidisc resulted in these production efficiencies:

ORDINARY DISC-TYPE		EIMCO AGIDISC
940 sq. ft. of filter area in 10 discs. It was necessary to by-pass one-fourth of tonnage past the filter to maintain required production level. Processed 17 tons of concentrate per day (75% of tonnage required for profitable operation).	**PRODUCTION COMPARISON**	1040 sq. ft. of filter area in 10 discs. Efficiently handles the tonnage that formerly was by-passed. Processes 24 tons of concentrate per day. With an increase of **25%** in filter area, the Eimco has boosted capacity by **40%.**
75% production efficiency was achieved only through considerable manual assistance. Excessive down time for filter tank cleaning.	**OPERATING EFFICIENCY**	In achieving 100% production efficiency, Eimco uses efforts of one man part time. Maintenance and labor costs are much less.
Poor cake discharge required manual assistance. Uneven cake formation. Severe classification rings on outer periphery of disc with thin, slimy cake near center.	**PRODUCT EXCELLENCE**	Efficient cake discharge without manual assistance. Ability of Agidisc to maintain uniform particle suspension has resulted in even, dry cake formations.

Outstanding success of the Eimco Agidisc Filter prompted this firm to convert five other disc filters into Agidiscs. They are convinced these installations are securing a ton of concentrate at the lowest cost per dollar of investment and maintenance.

Increasing the efficiency of your plant means greater returns. The Eimco Research and Development Center is staffed and equipped to help you solve your filtration problem whatever it may be. They'll be happy to assist you!

THE EIMCO CORPORATION

SALT LAKE CITY, UTAH

Research and Development Division, Palatine, Illinois • Process Engineers Inc. Division, San Mateo, California
Export Offices: Eimco Building, 51-52 South Street, New York 5, N. Y.
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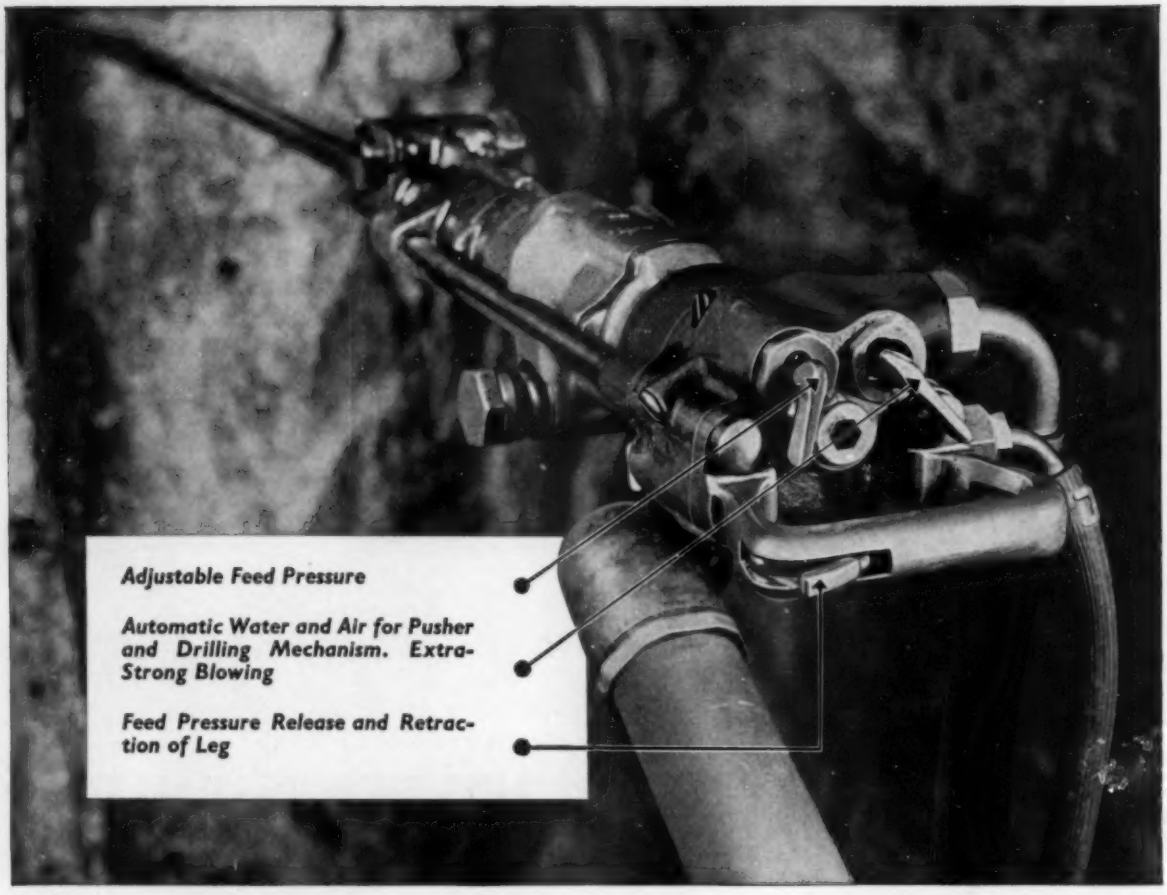
B-241


Adjustable Feed Pressure
Automatic Water and Air for Pusher and Drilling Mechanism. Extra-Strong Blowing
Feed Pressure Release and Retraction of Leg

RETRACTABLE LEG AND ONE-HAND GRIP-CONTROLS SPEED DRILLING TIME

For years Atlas Copco have been the world's largest manufacturers of pusher leg drills. Since 1937 when Atlas Copco, far ahead of any other manufacturer, introduced their first pusher leg drills, they have continuously improved the design of these drills. Their latest development, the Atlas Copco 'Lion', combines an unequalled ease of operation together with a high drilling rate—both contributing to a higher footage per manshift.

All controls under one hand

The Atlas Copco Lion is the first drill to have all the valves which operate the drill under the control of one hand. *Full control without having to move the hand from the backhead!*

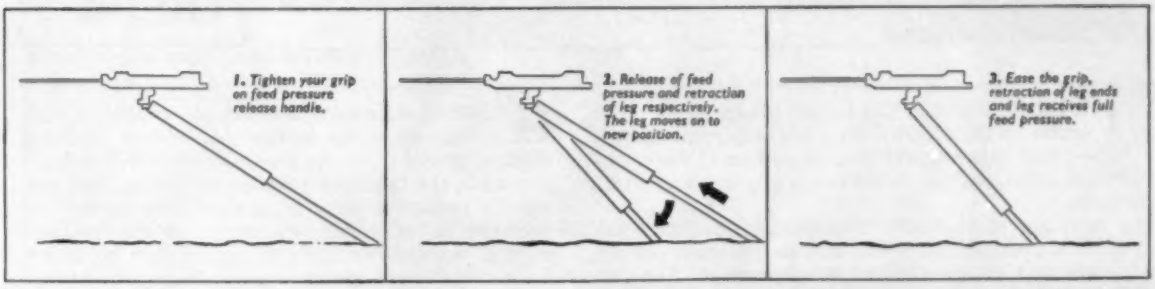
The valves are all easy to operate. By the use of only the fingertips the drill can be started or shut off, the feed can be adjusted to the pressure required, or retracted for an advance, and the extra air-blowing can be brought on to clean the holes.

All the control handles have been designed in such a way that they are well protected. While using them the operator's hand is never near the wall or roof of the drift. The Lion is the first pusher leg drill with controls placed for drifting.

Retractable leg saves time

When the leg has to be moved the feed pressure is easily released by squeezing the hand grip. By further pressure on the grip the leg retracts automatically.

Pusher leg moves forward with drill in full action


1. Tighten your grip on feed pressure release handle.
2. Release of feed pressure and retraction of leg respectively. The leg moves on to new position.
3. Ease the grip, retraction of leg ends and leg receives full feed pressure.

When the leg is in the new position suitable for continuous drilling, retraction stops and the feed pressure comes back by loosening the grip of the hand. *All this can be done while the drill is still running.*

This new idea of a retractable leg enables quicker repositioning of the leg and reduces the number of steel changes, thereby increasing footage per manshift. When drilling high holes it is now far easier to alter the position of the leg more frequently in order to maintain an optimal feed angle and feed pressure.

Packed with power for deep holes

The Lion has a drilling rate at least 30% higher than other rock drills of the same weight. Furthermore, it is designed so that it can maintain its high speed *even when drilling deep holes.* This means quickly drilled deep hole rounds and a faster, steadier advance. You'll also find that the Lion reduces *to a minimum* the gauge wear of the bits in abrasive rock. And owing to the ease with which the feed pressure is released and brought back into action, the Lion is a *handier* drill to work with in fissured rock.

Sandvik Coromant—the right steel for the Lion

All Atlas Copco drills—and this goes for the Lion—have been developed from the earliest stages with Sandvik Coromant tungsten-carbide-tipped integral steels and detachable bits. No drill or steel developed separately could ever give such equivalently high performances as this drilling combination. It is today the most widely used in the world, responsible for drilling more than one billion feet per year.

Free Demonstration! *Wire, 'phone or write* today *to any one of these offices and see the Atlas Copco Lion in action for yourself.*

U.S., Atlas Copco Pacific, Inc., 930 Brittan Avenue, San Carlos, California. Atlas Copco Eastern, Inc, P.O. Box 2568, Paterson 25, N.J.

CANADA, Atlas Copco Canada Ltd., Montreal Airport, P.Q.

MEXICO, Atlas Copco Mexicana S.A., Apartado 56, Torreon, Coahuila.

The ATLAS COPCO GROUP puts compressed air to work for the world. It is the largest group of companies specializing solely in the development and manufacture of compressed air equipment. It embraces Atlas Copco companies or agents manufacturing or selling and servicing Atlas Copco equipment in ninety countries throughout the world.

Without changing the grip of the hand the driller can easily position and control the machine, saving time and reducing fatigue.

Atlas Copco

Manufacturers of Stationary and Portable Compressors, Rock-Drilling Equipment, Loaders, Pneumatic Tools and Paint-Spraying Equipment

TRENDS' new look this month is temporary. The tables on the opposite page are important enough to warrant this month's change of face if the number of questions we receive monthly are any indication.

Revision of the AEC Declassification Guide has made it possible to release data on uranium ore reserves and on production subsequent to June 30, 1955. Foreign suppliers will determine when their own operations are to be put before the public eye, but the classification clamp on U. S. production figures before that date is still down tight.

During 1956 the AEC discontinued the aerial prospecting program that was begun in 1953, but no stemming of exploration resulted. The AEC notes the following private work during the year:

> Intensive private drilling has expanded the boundaries and is continuing to expand the reserves of the Ambrosia Lake district, northwest of Grants, N. M.; the Gas Hills district of Wyoming; Monument Valley, northern Arizona; and the northeast Washington area. Noteworthy developments in outlying districts were further discoveries near Lakeview, Ore.; in the Pryor and Big Horn Mountains in Montana and Wyoming; in the Gunnison area of Colorado; and in the Texas Gulf Coastal region. There has also been continued activity in the lignite areas of North and South Dakota, although these areas have not indicated the potential originally anticipated after their discovery in 1954 . . .

Twelve uranium mills are in operation at present, and these (except for the AEC unit at Monticello, Utah) represent an estimated $50 million in private investment. Projected mills will cost over $35 million and the AEC has received proposals from several companies to build still more plants.

◆◆◆◆◆◆

SCIENTIFIC research, at government expense, is currently a $2.7-billion undertaking yearly. More and more of this industrially important information is being put into the hands of private industry, for the mere cost of reproduction and handling, through the Office of Technical Services, U. S. Dept. of Commerce.

Besides research reports, OTS publishes abstracts of patents that may be used non-exclusively and at no cost. In some fields subject catalogs of available data have been prepared. In addition two monthly bulletins cover published items that are newly offered. From 300 to 600 reports are described each month in the bibliography *U. S. Government Research Reports;* and the other publication, *Technical Reports Newsletter,* gives details on 15 to 20 reports of the widest general value. The first-mentioned monthly cost $6 per year, and the Newsletter is available at $1 per year. Both publications may be ordered from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

HANGING on a state decision for or against supplying Reynolds Metals Co. with a block of electric power from the St. Lawrence hydroelectric project is the tentative plan for an $88 million aluminum reduction plant in upstate New York. The problem in approval lies with varying political opinion on whether the area would best be served by distributing a given amount of power through a contract with Reynolds, or if more and diversified industrial projects could be attracted to the area. If the legislature grants the needed power New York will make another big jump in its aluminum processing capacity. The proposed plant, to be located seven miles from the Alcoa plant at Massena, N. Y., would have an annual output of 200 million lb. Reynolds' total annual production would, in turn, be raised to approximately 700,000 tons.

◆◆◆◆◆◆

STEELMAKING *capacity* of the U. S. during 1956 increased to the highest level yet reached, 133,459,150 net tons, according to B. F. Fairless, president, American Iron & Steel Institute. The new figure is an increase of 5,096,060 tons over the previous year and the American steel industry can now produce more than 40 pct of world output, he said.

Capacity has been increased for each of the ten years past, and is 45 pct higher than at the end of World War II. Since the war, it is estimated, more than $8 billion has been spent by iron and steel companies for new equipment and construction.

Other producing facilities expanded and improved in support, said Mr. Fairless. Raw material supply has increased. Blast furnace capacity went up 1,332,720 net tons during 1956, and as of Jan. 1, it is rated at 86,817,950 tons annually. Coke oven capacity is now rated at 72,970,980 tons a year. Weekly capacity of ingots and steels for castings is now 2,559,490 net tons.

◆◆◆◆◆◆

LACK of electric power means development slowed all out of proportion to the potential of many a remote area of the world. Construction of generating plants for large-scale harnessing of water power or for the use of huge quantities of fuel are highly economical in the long run. But what is needed in inaccessible areas is a power facility that may be put to use with speed and minimum trouble. The solution that still another company has been noted investigating is a miniature plant that will use nuclear energy for the generation of electricity. The plant envisioned will be small and easily transportable. It is not expected to be a cheap source of power, but the time it can save in start-up work will more than compensate for the expense. A mining enterprise with several of the units might even specialize in developing the roughest hinterland.

DOMESTIC URANIUM PRODUCTION AND ORE RESERVES

Uranium Ore and Concentrate Production

1955	Tons Uranium Ore	Tons U_3O_8
July-December	840,000	1600
1956		
January-June	1,340,000	2600
July-December	1,660,000*	3400**
Total 1956	3,000,000	6000

* Last quarter estimated.
** December estimated.

Uranium Ore Reserves*

Area	Tons	Pct U_3O_8	Pct of Total Ore
New Mexico	41,000,000	.24	68.4
Utah	7,500,000	.34	12.5
Colorado	4,100,000	.33	6.8
Arizona	2,600,000	.30	4.3
Wyoming	2,300,000	.22	3.8
Washington	1,500,000	.18	2.5
Others	1,000,000	.24	1.7
Total	60,000,000	.25	100.0

* Estimated domestic reserves of measured, indicated, and inferred ore as of Nov. 1, 1956.

Uranium Mills in Operation

Name	Location	Ore Capacity (tpd)
The Anaconda Co.	Bluewater, N. M.	3000
Atomic Energy Commission*	Monticello, Utah	600
Climax Uranium Co.	Grand Junction, Colo.	350
Kerr-McGee Oil Industries Inc.	Shiprock, N. M.	500
Mines Development Inc.	Edgemont, S. D.	300
Rare Metals Corp.	Tuba City, Ariz.	250
Union Carbide Nuclear Co.	Uravan, Colo.	850
Union Carbide Nuclear Co.	Rifle, Colo.	280
Uranium Reduction Co.	Moab, Utah	1500
Vanadium Corp. of America	Durango, Colo.	430
Vanadium Corp. of America	Naturita, Colo.	350
Vitro Uranium Co.	Salt Lake City	550
	Total	8960

* Operated by National Lead Co.

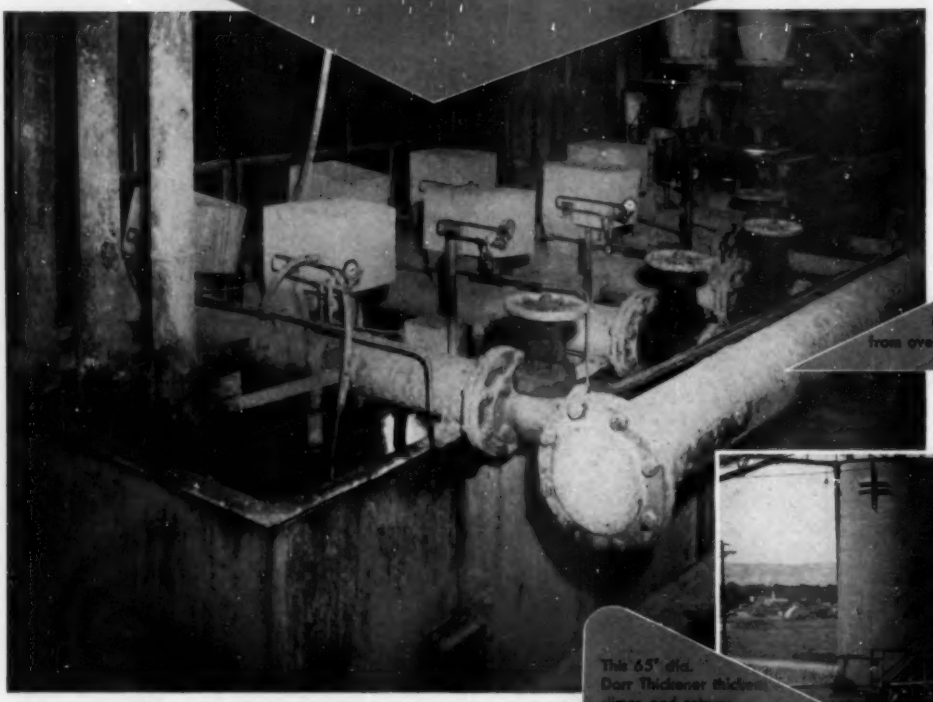
Uranium Mills Projected

Name	Location	Rated Ore Capacity (tpd)
Atomic Fuels Extraction Co.	Bedrock, Colo.	200
Dawn Mining Co.	Ford, Wash.	400
Gunnison Mining Co.	Gunnison, Colo.	200
Homestake-New Mexico Partners	Grants, N. M.	750
Lost Creek Oil & Uranium Co.	Split Rock, Wyo.	400
Lucky Mc Uranium Corp.	Fremont County, Wyo.	750
Trace Elements Corp.	Maybell, Colo.	300
Texas-Zinc Minerals Co.	Mexican Hat, Utah	775
Union Carbide Nuclear Co.	Rifle, Colo.	1000*
	Total	4775

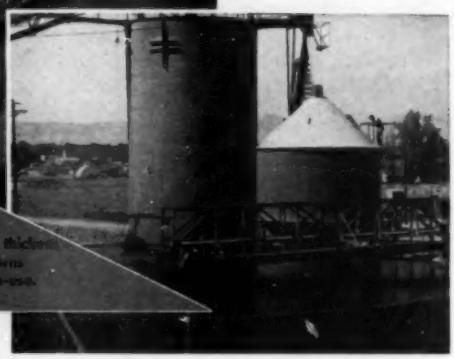
* Including ore fed to concentrating plants.

DORRCO *JET* SIZER

at Climax Uranium...



Closeup of Dorrco Jet Sizer at Climax Uranium taken from overflow end of machine.



This 65' dia. Dorr Thickener thickens slimes and returns overflow for re-use.

Earliest producer on the Colorado Plateau, Climax Uranium uses Dorr-Oliver equipment for key classification, thickening and filtration steps throughout the flowsheet. The initial sand-slime separation is made in a 7½ pocket Dorrco Jet Sizer. Feed to the unit is 400 TPD of all 28 mesh material which is split at 150 mesh. A hindered settling classifier, the Dorrco Jet Sizer utilizes an overhead, removable hydraulic water distribution system which eliminates costly constriction plate construction. Adjustments to changes in feed composition are automatic to insure constant pulp density and product quality.

Sizer spigot product goes to leach tanks and sizer overflow (−150 mesh) to a 65′ dia. Dorr Thickener. Thickener overflow is returned for re-use and underflow is sent to process. A 50′ dia. and 24′ dia. Dorr Thickener are also installed at Climax along with a number of Dorrco VM Pumps.

In the leaching section an 11′6″ x 12′ Oliver Panel Filter performs a liquid-solids separation on the leached uranium ore. Employing a floating cake discharger, the Panel Filter is ideal for handling slow filtering products forming slimy cakes.

For more information on the complete line of D-O equipment for the mining industry, write for a copy of bulletin No. 2200. Dorr-Oliver Incorporated, Stamford, Connecticut

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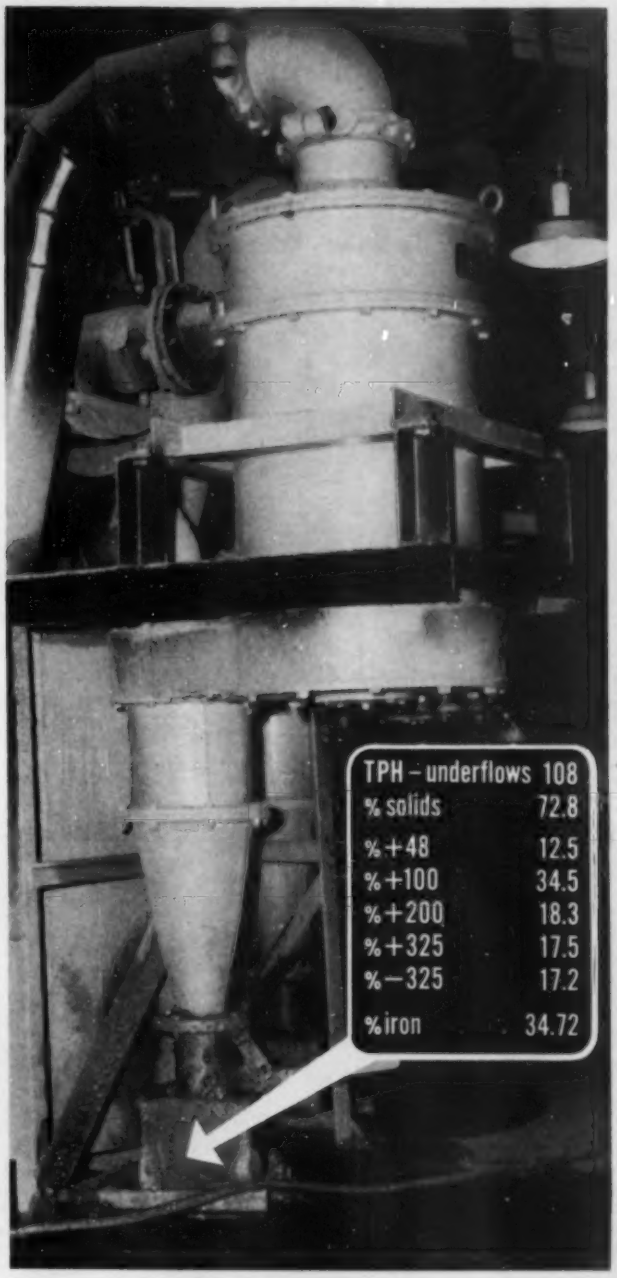
Here is a new technique for recovery of values from tailings

A new economical method for additional recovery was developed in 1954 at this Mesabi Range iron ore beneficiation plant by the use of Krebs Cyclones. A battery of 10 Model EE20-9B integral two stage Krebs Cyclones* handles 5840 gpm (281tph) with the primary overflow rejecting paint slime and the secondary overflow rejecting fine sizes high in silica and low in iron. This is an exceptionally sharp split. Upgrading from 20.75% Fe to 34.72% Fe into crystalline sizes makes an ideal feed for the subsequent concentration to required grade.

This recovery technique has now been adopted by 14 other iron plants throughout the world and has also been applied to tailings from plants handling ores of chrome, manganese, copper, lead-zinc, tin, tungsten, gold-silver.

We invite you to consult us on the advantages of Krebs Cyclones to your operations.

*Patented



KREBS INTEGRAL TWO STAGE CYCLONE

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Manufacturers of Krebs Cyclones, Valves and Clarkson Feeders

Nordberg

GRINDING

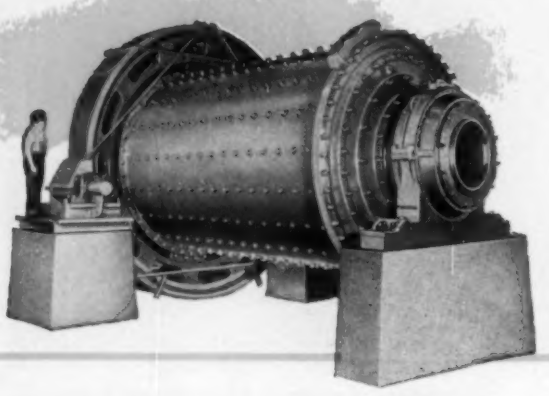
. . . built to meet the exacting requirements of the MINING INDUSTRY

NORDBERG MACHINERY is the result of specialized engineering skills aided by unsurpassed manufacturing facilities. For over half a century Nordberg has produced heavy machinery for the mining industry, which has become well known all over the world for its advanced engineering, excellent construction, high efficiency and dependable service.

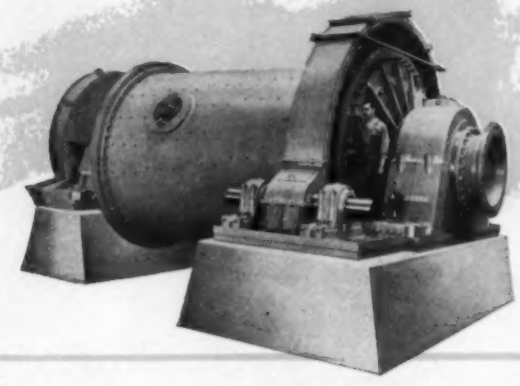
Included in this broad line of heavy machinery is the complete line of Nordberg Grinding Mills, designed and built to meet the most exacting requirements of the mining industry . . . for wet or dry grinding of metallic and non-metallic minerals, and in other processes where friable material must be comminuted to fine sizes.

Nordberg Grinding Mills are manufactured in sizes ranging from 6 to 13 feet in diameter and up to 50 feet in length. Types include Ball, Pebble, Rod, Tube and Compartment Mills.
Write for further information.

NORDBERG MFG. CO., Milwaukee, Wisconsin



Typical Nordberg dry grinding Rod Mill, measuring 10'-6" in diameter by 16' in length, for ore processing service. Mills of this type are in wide use in the mining industry, delivering maximum output at lowest possible cost.



• View showing discharge end of Nordberg 10'-8" x 17' wet grinding Ball Mill with Scoop Feeder. Whether wet or dry process, open or closed circuit operation, there is a Nordberg Grinding Mill built for the job.

SYMONS GYRATORY CRUSHERS

SYMONS CONE CRUSHERS

NORDBERG KILNS AND COOLERS

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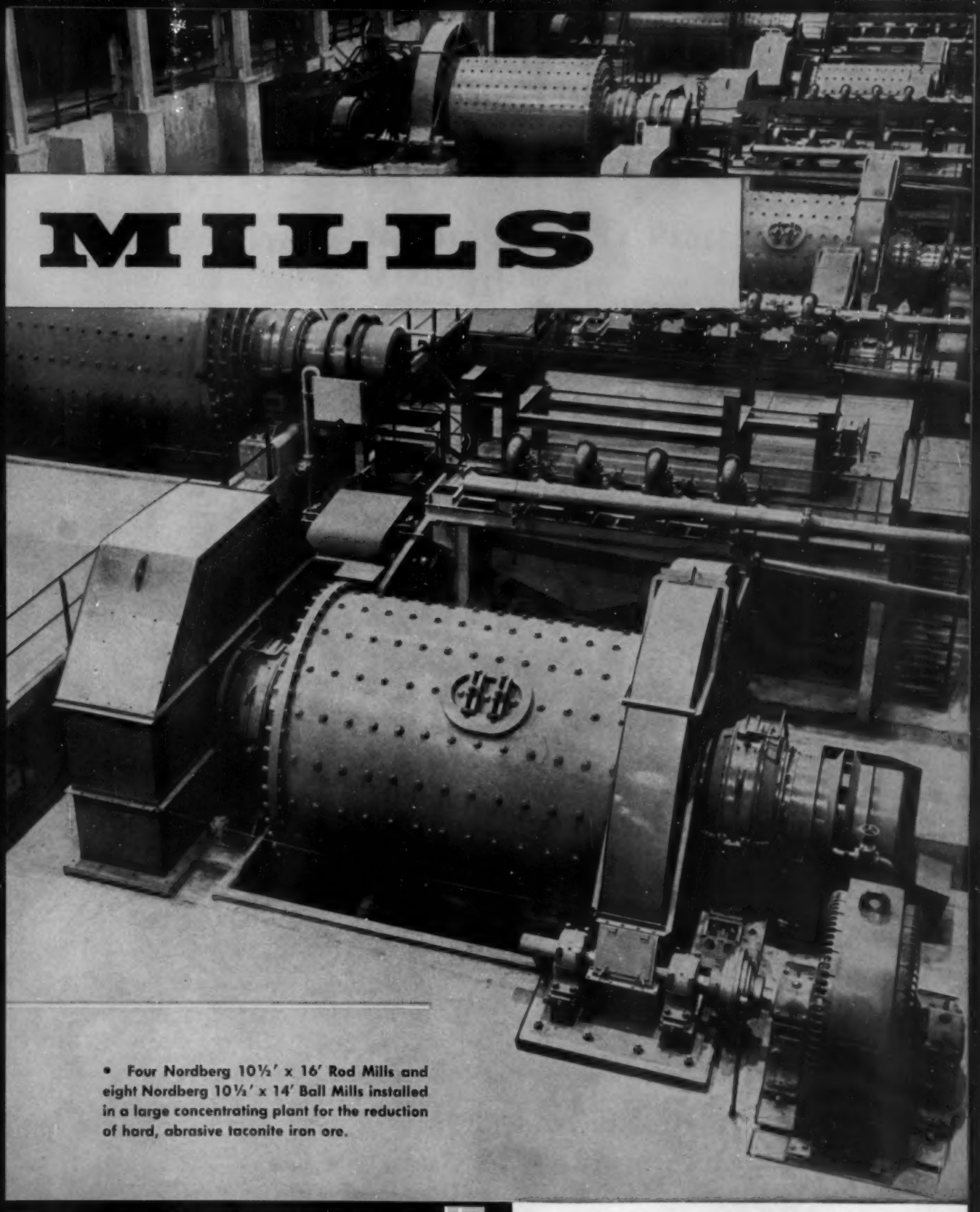
NORDBERG DIESEL • DUAFUEL® and SPARK-IGNITION GAS ENGINES



MILLS

• Four Nordberg 10½′ x 16′ Rod Mills and eight Nordberg 10½′ x 14′ Ball Mills installed in a large concentrating plant for the reduction of hard, abrasive taconite iron ore.

NORDBERG

MACHINERY FOR PROCESSING ORES and INDUSTRIAL MINERALS

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SYMONS . . .

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GH-156

SULPHUR

helps to create headline products

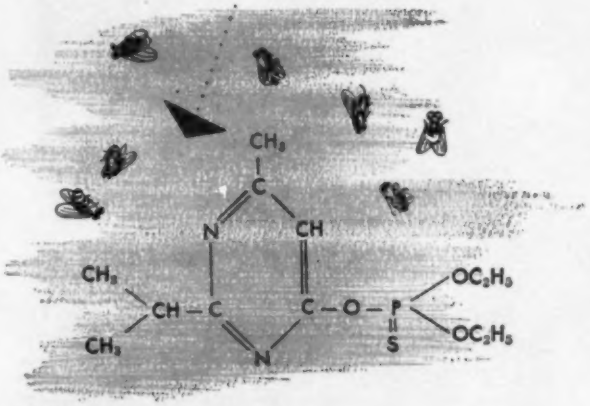
DIAZINON*

What a 'killer' this complex chemical is turning out to be! And quite impartial as to its victims: — houseflies, barnflies, fruitflies, aphids, mites, ants, beetles, chinch bugs, roaches, and many other pests that bother man and beast. It kills them dead!

As with the former chemicals which made such notable headway in man's fight to subdue these destructive pests, Sulphur is very much in the picture—here is one of the many variations of the benzene ring . . . the Diazinon Formula. That letter "S" tied in with the letter "P" discloses the all-important thiophosphate.

Sulphur, often called one of the Four Pillars of the Processing Industry, is benefiting mankind in many ways. None is more important than that of controlling crop-destroying pests.

**A product of the Geigy Chemical Corporation.*



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Dependable POWER

for Ore and Rock Processing

Apply the many cost-saving features of Allis-Chalmers deep rib motor in a variety of processes... both indoors and out.

Here's why these motors offer more dependability in quarrying and mining operations:

MORE Cooling Surface — Rib-type design provides reserve cooling capacity—an important factor in dirty locations.

MORE Iron — Cast-iron frame and external parts assure greater rigidity and resistance to corrosion.

MORE Copper — Greater use of copper increases electrical life.

MORE Lubrication Provisions — Large grease reservoirs surround bearings. Provision made for in-service lubrication — important where moisture or corrosive vapors contaminate grease.

Rib-Type MOTORS 1 to 100 hp

Allis-Chalmers offers rib construction in all enclosed motors from 1 to 100 hp (through frame 505). To find out more about A-C motors, contact your nearby A-C distributor or district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

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KENNEDY

For

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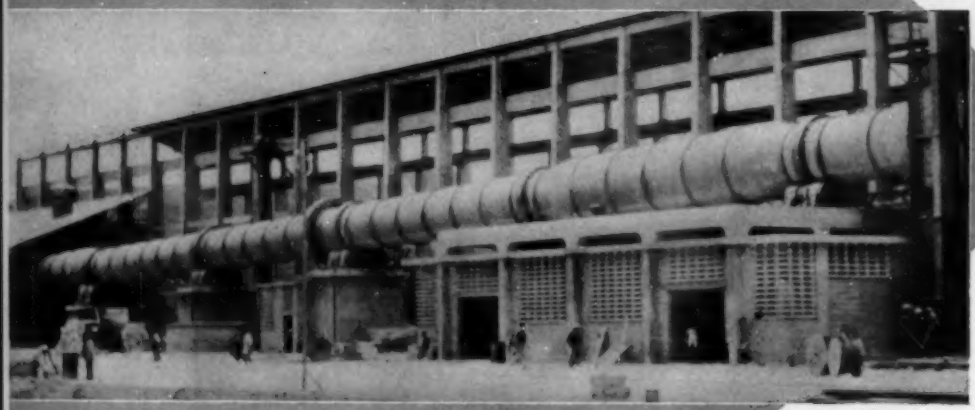
Lime
Calcined Coke
Dead Burned Dolomite
Nodulizing and Agglomerating



Kennedy 9' x 11' x 350' Rotary Kiln being installed in Wet Process Cement Plant.

In use throughout the world by many of the largest producers of the materials which are vital in today's industrial program, Kennedy Kilns are designed to operate economically, efficiently under all conditions with lowest maintenance costs. Built in any length or diameter.

KENNEDY-VAN SAUN

Rotary Kilns

FOR FUEL ECONOMY, KENNEDY KILNS CAN BE SUPPLIED WITH

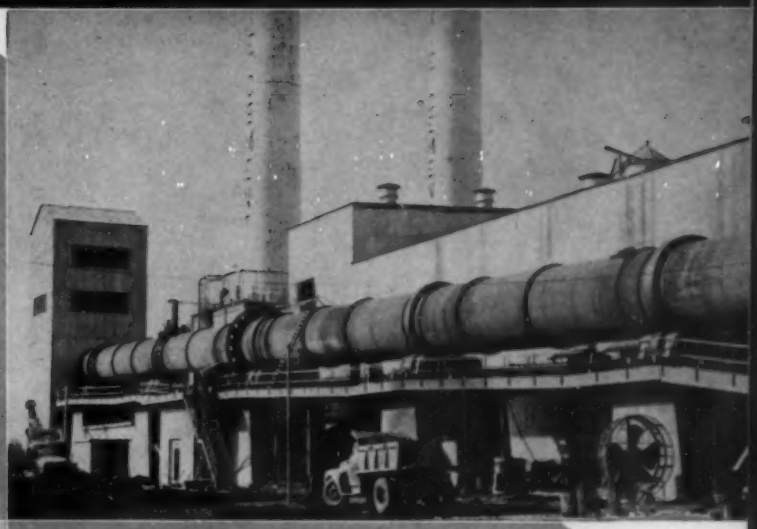
ennedy Multivane Internal Recuperator

or

Kennedy-Grudex External Preheater

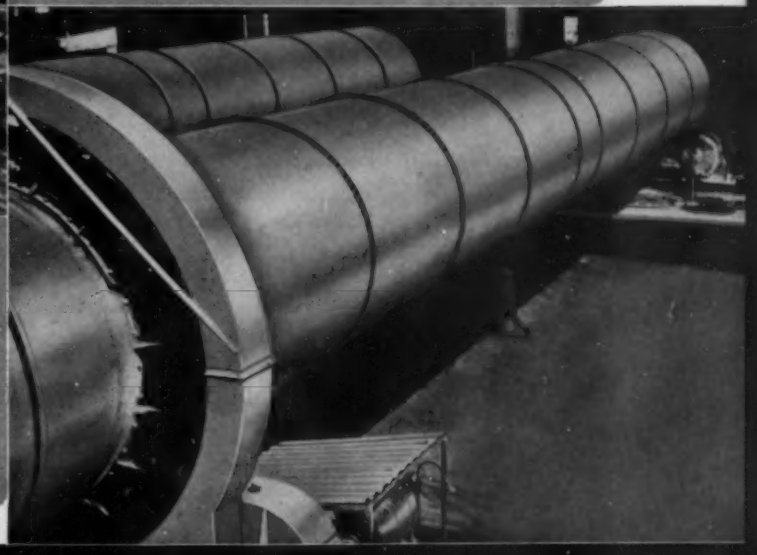
or

Kennedy External Stone Preheater



Kennedy, 11'x375' Rotary Kiln in Wet Process Plant.

Two, 10'x173' Kennedy Rotary Kilns, in Dry Process Cement Plant.



Two, 11'x375' Kennedy Rotary Kilns in process of erection at 5,000 Barrels per day, Wet process Cement Plant.

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GROVER J. HOLT

AIME President 1957

GROVER J. HOLT, member of the Institute since 1941, was born in Northwood, N. D., in 1894. After receiving a B.S. degree in mining engineering in 1916 from the University of North Dakota, he became a research fellow in metallurgy at the University of Utah and last year was awarded the honorary degree of Doctor of Engineering by the Michigan College of Mining & Technology.

His career has provided professional contact with a wide range of the mineral industry—from western nonferrous operations to all aspects of iron ore and its preparation for blast furnace use.

During World War I he served with the AEF as a Lieutenant, U. S. Army Engineers, and following this service spent two years in the Bunker Hill & Sullivan smelter and underground properties at Kellogg, Idaho.

In 1920, Mr. Holt joined U. S. Steel Corp. as a mining engineer and has made the Lake Superior iron range region his home area ever since. Here his activities have covered the full scope of mining and beneficiation in the areas of operation, research, and finally overall management.

He became assistant to the vice president of Butler Brothers in 1930 and during the next decade was active in pointing out depletion of reserves of direct shipping iron ore, and in developing methods to process lower grade reserves.

In 1940–1941 he designed the first sink-float installation using ferrosilicon media, which was placed in operation at Butler's Patrick plant, and also presented the first paper on the application of this process at an AIME session during that period.

One credo for the engineer says, "First be sure, then go ahead." The ability to determine the crucial point—when you are really sure—is the mark of a doer, not the dreamer. The doer must also have the facts. Mr. Holt has not only pioneered in iron ore research himself—he early recognized its importance to development of the remaining reserves of our basic raw materials for the making of steel.

They tell one story that perhaps best defines the difference between the dedicated researcher after knowledge for its own sake, and the engineer who must balance the search for the truth with the need for action. It seems that Grover Holt and one of his top technical people were riding across the Minnesota farm country when they passed a flock of sheep. Mr. Holt commented that the sheep had recently been closely sheared. The research man agreed—with qualifications—"At least they are on this side."

Mr. Holt joined the Cleveland-Cliffs Iron Co. as Chief Engineer in 1942, becoming Manager, Minnesota Mines, in 1950, and General Manager of Mines for Minnesota and Michigan in 1953. Here his role has been that of a builder. During this period CCI established a beneficiation laboratory, and from work done there and in the Engineering Dept., a succession of plants have sprung up to treat Minnesota and Michigan low grade ores.

In first seeing the problem: diminishing reserves of direct shipping ore, and then taking the steps to meet these problems, Grover Holt has an outstanding record of participation in first steps. During the 1930's he joined the few who spoke out at that time about the ore needs of the future; before World War II he delivered the first paper on the corner stone process of intermediate grade ore beneficiation: heavy media, now used almost universally on the range and elsewhere for coarse ore concentration.

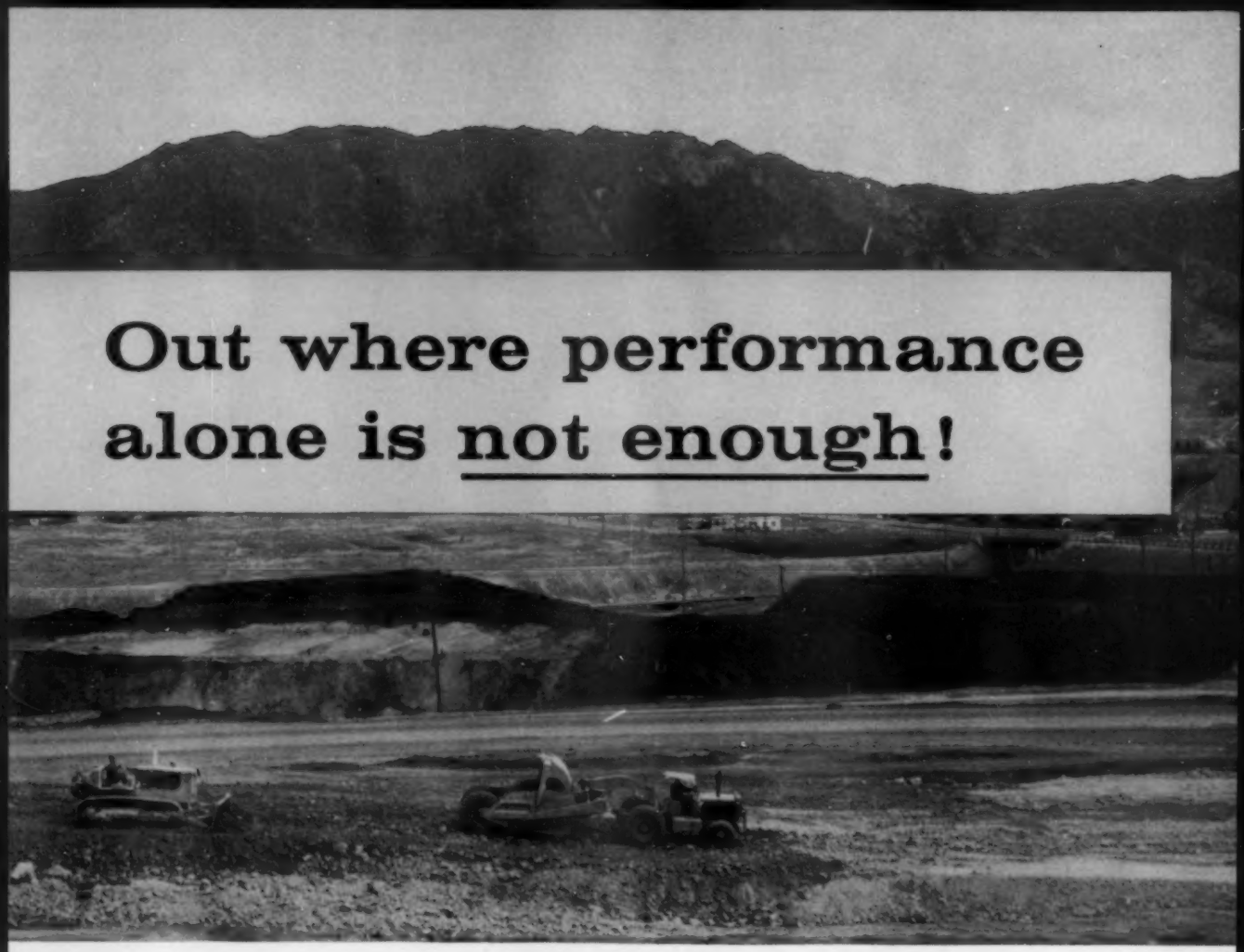
In 1943 CCI was one of the first companies to build a new laboratory to tackle beneficiation problems. Also, more recently the CCI company in Michigan put into operation the first commercial iron ore flotation plant.

Foresight without the ability to plan ahead is of little value. It is perhaps significant CCI's plants of recent years have had ample and detailed testing, development, and planning behind them.

At a turning point in AIME development, Grover Holt comes well prepared to the task of the Presidency. Having played a major role in drafting the new By-laws, he brings a unique background to a unique opportunity. His will be the task of guiding the first and formative year of operation under a new pattern which he helped design.

For the future, ways must be found to take advantage of the flexibility of the three-society framework, while retaining the values of the stability and strength of the Institute. Foresight and ability to plan for the future will stand AIME in as good stead as it has the iron ore industry.

Mr. Holt lives in Ishpeming, Mich., where he *occasionally* has an opportunity to take advantage of the excellent local hunting and fishing facilities in that area.



Out where performance alone is not enough!

Near Butte, Montana, a CAT* DW20 Tractor works on a haul road at an open-pit copper mining operation. The road, half a mile long and 60 feet wide, had to go in fast. So a pair of DW20s with Scrapers dumped some 1600 cu. yd. of dirt per 8-hour day, and did it day in, day out till the job was done.

And that's the point: *day in, day out* till the job is done. For, on the hard jobs, performance alone, while mighty important, is not enough.

Sure, DW20 units give superior performance. Big capacity. Load easily. Big rimpulls that overcome grade and rolling resistance on rough roads. Ejection that gets rid of any kind of material quick. And, of course, high speed.

But the DW20 does more than a good job. It *stays* on that job. It shrugs off the down time that hurts you in your cost-per-yard figure. Your Caterpillar Dealer is ready with facts and figures to prove that the built-in durability of the DW20 means dollars and cents to you. He's ready, too, with expert service—and with replacement parts you *know* you can trust.

P.S.: Your Caterpillar Dealer will demonstrate the DW20 on your job, at your say-so—with any of its famous running mates: the new No. 456 Scraper with LOWBOWL design; the Athey PH20 Wagon specifically designed as an economical coal hauler (56 cu. yd. heaped load); and the Athey PD20 side dump Wagon with a heaped capacity of 25 cu. yd.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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WANTED—THE HARD WORK

Annual Review

The Editorial Staff takes pleasure in dedicating this Annual Review issue to E. H. Robie, AIME Secretary, retired. The AIME Directors' commemoration of his 25 years service to the Institute appears on page 272.

Underground Mining

Mining companies continue to introduce new techniques—Brower Dellinger, *Manager of Monticello plant, National Lead Co. Inc., Monticello, Utah.*

Mining Geology

More money was being spent and more people were engaged in research than ever before—P. W. Guild, *Geologist, U. S. Geological Survey Washington 25, D. C.*

Beneficiation

Shortage of competent young engineers and technicians is stunting the natural growth of theoretical investigation in the field of mineral beneficiation—Norman Weiss, *Milling Engineer, American Smelting and Refining Co., Salt Lake City, Utah.*

Geophysics and Geochemistry

In exploration it has been found that geophysics and geochemistry are not in competition with each other, but rather, offer supplemental information—Ralph C. Holmer, *Chief Geophysicist.*

Coal

The need for intensified research is stressed with comparison to the percentage expended on research in other industries. Mechanization continues to move ahead, entering still more complex phases.

Open Pit

East or West the problem is the same—finding the most efficient way to do a massive and selective earthmoving job, while handling the most difficult and abrasive of natural materials.

Underground Mining — The Trends in 1956

Edited and Compiled by Brower Dellinger

General Manager, National Lead Co., Inc.

U. S. mining trends for 1956 continued steadily uphill, technique and equipment advanced with the pull, and exploration and development of once mined districts attracted more attention than new areas. Expansion of the Ambrosia Lake district in New Mexico more than doubled known uranium ore reserves, and production began from several of the large new ore discoveries. In Canada the up trend was more spectacular, especially in exploration and development.

To combat increasing problems arising from high labor costs, taxes, low grade orebodies, and dwindling discoveries, manufacturers and mining companies have continued to introduce new techniques and new products—reamer bits for enlarging small holes drilled by jacklegs, whup d'whups for drift mucking, Cryderman machines and over-the-head small crawler-type machines for shaft mucking, the 20-ton TL 220 four-wheeled tractor trailer unit for underground haulage, inertia-type dust collectors, roof bolting in conjunction with chain link fencing for wall support, wooden roof bolting using compression support of ground for wall support, and new one-use carbide bits.

Only in neglecting to establish a sound mineral policy has the country failed to keep pace. It is of grave concern to the mining industry that the U. S. has changed from a raw material exporting nation to an importing nation, and help is needed to formulate a long-range policy that will stimulate domestic exploration and development. This policy must incorporate a revision in depletion allowances, the right to charge exploration costs against income, and a free start-up period of at least three years for new mines. Many major companies have been forced into diversification and investment in foreign fields to protect assets and stockholders.

In Canada the mineral industry reached its greatest peak in history, production exceeding $2 billion. In uranium alone tremendous sums were raised by loan and bond issues for development and production. Nickel, lead, zinc, and copper expanded at ever increasing rates, and even gold mining, with all the hardships, managed to maintain production. The fair treatment received from the Canadian government cannot be minimized in helping to reach these achievements.

by Hugh Steele

San Manuel Copper Corp.

Arizona–New Mexico

Production from the underground mine, **Miami Copper Co.**, for the year 1956 came from the low grade orebody. Scheduled production was 12,000 tpd, 6 days per week, on a two-shift basis with a skeleton maintenance crew on C shaft.

The shape of the orebody is such that it must be mined on three levels, the 570, 720, and the 900. Haulage is on the 1000 level. On the 570 and 720 levels lateral transfer from the two lower levels to the ore passes is effected by 36-in. conveyors.

All stopes, with the exception of one full gravity stope, are being pulled with scrapers into transfer raises which either feed onto the belt conveyors or into 4-ton haulage cars.

Magma Copper Co. is continuing exploration of the **East Replacement orebody** by diamond drilling the downward extension to about the 3600 level. The upward extension above the 2800 level and west of a major cutoff fault are being explored and developed by raises.

Application of jacklegs in drilling is increasing both in stopes and drifts. Extensive testing is being done on the use of the single-use tungsten carbide bit and carburized drill rods.

Rock bolting is increasing, mainly in drifts and stations. The use of chain-line type fencing with the rock bolts is proving satisfactory in many places.

San Manuel Copper Corp. has, at the present time, five full gravity blocks and one slusher-type block in operation. Present mine production is more than 20,000 tpd.

Stope development is continuing at the scheduled rate of progress and with the increased use of concrete for grizzly drift and grizzly panel fringe drift ground support. About 60 cu yd of concrete per day are being poured now.

Roof-bolting with wire mesh for ground support prior to setting the forms and concreting is proving satisfactory, with light timber support required in a few places.

The **Shattuck-Denn** lead-zinc property, **Iron King mine** at Humboldt, Ariz., is producing 800 tpd of lead-zinc ore.

Mining is by horizontal cut and fill stoping, with vertical level intervals of 130 ft. Three-compartment raises are driven every 400 ft in the ore to the level above and are used for introducing fill into the stopes on each side of the raise. Sufficient fill for the stoping is drawn from a block cave area in the hanging wall on the 600 level. Stopers with carbide bits and alloy steel are used for drilling the stope back.

During the year the No. 7 shaft has been deepened to the 19th level.

The **Johnson Camp mine** of **Coronado Copper & Zinc Co.**, near Dragoon, Ariz., is producing about 200 tpd. The orebodies occur as replacements in limestone. Most of them rake flatly up the beds which dip from 30° to 40°.

The mining employed is chiefly room and pillar and sublevel stoping.

Development is by raise along the hanging wall in the middle of the block, followed by slabbing on both sides to a 40-ft width. The back is secured by roof bolting. Drilling for blasting of the stopes is done by ring drilling with percussion drills from sublevel crosscuts in the middle of the blocks.

Banner Mining Co. is operating the **Daisy** and **Mineral Hill mines** south of Tucson with a production of about 600 tpd. Cut and fill stoping methods are used at both mines. At the **Mineral Hill mine,** mill tailings are deslimed by a cyclone and piped underground for stope filling. Longhole drilling by percussion drills is used to test the walls up to depths of 100 ft.

The **Glance mine** at Twin Buttes is being developed and will go into production early in 1957. It will produce copper ores at the rate of 200 tpd which will be milled in the **Mineral Hill** mill.

Capacity of the Mineral Hill mill is in the process of being expanded to 1000 tpd from the present 500-ton capacity. Completion of the new unit is expected in November 1956.

The **New Mexico Consolidated Mining Co. Kearney mine,** located between Santa Rita and Hanover, N. M., is operating on zinc replacement orebodies occurring along pre-ore dikes and fractures. A diamond drill program aimed at drilling out favorable areas precedes development and extraction headings.

When ore areas are reached by the development headings, a typical method of slash mining is used, applying Jacklegs ⅞-in. steel and carset bits. Because some secondary breaking is necessary ore is dropped to the floor and loaded into 20-cu ft cars by Gardner-Denver loaders. Both hand tramming and Mancha locomotives are utilized for ore transportation to the shaft, caging is used, and milling is done at Deming.

The **Ground Hog mine** of **American Smelting & Refining Co.** resumed operations in March 1955 after a two-year shutdown. Early in 1956 underground development was increased. Stoping has primarily been by unfilled square set method, but through increased use of roof bolts for back and side bolting more areas are mined by cut and fill methods, thus allowing for more effective disposal of waste underground. Roof bolts, in conjunction with chain link fencing, have also made it possible to mine more areas by open stoping. A program of deep drilling to lower limestone horizons is in progress.

Ore is milled at Deming in a modern 500-tpd selective flotation plant. A limited amount of custom ore is milled each month.

Banner Mining Co. is operating the **Bonney** and **Misers Chest** mines at Lordsburg, N. M. Production from these mines averages about 270 tons of copper ores per day, all of which is milled in the 400-ton flotation mill located at the mines. All mining at Lordsburg is by the shrinkage stoping method.

U.S. Potash Co., Division of **U.S. Borax & Chemical Corp.,** mines, refines and ships potassium chloride near Carlsbad, N. M. The mine is located approximately 24 miles northeast of the city of Carlsbad and consists of three shafts approximately 1000 ft deep. The No. 1 and No. 2 shafts are used for mining the original orebody found by Snowden McSweeney Oil Co. 29 years ago while drilling for oil in the Twin Hills area. The No. 3 shaft 6 miles to the north has opened up a new area that is to be mined by continuous miners and conveyor belts. The room and pillar method is utilized.

The company has just completed an approximate $3 million expansion to the refinery and mine to increase the production about 20 pct. Completion of a new shaft to the new developments will be continuous with miners and conveyor belts only.

A new storage warehouse of 100,000-ton capacity is under construction at the refinery site to be better able to service their customers on a seasonal basis.

International Minerals & Chemical Corp. has increased mine production the past year by:

1) Addition of rubber-tired Universal-type cutting machines, replacing the standard shortwall types in all production areas.

2) Conversion of the two-man operated Jumbo drills to one-man operation.

3) Brake cars using modern streetcar type magnetic rail brakes to permit greater speeds on downhill hauls.

4) The placing in service of self-powered mantrip jeeps, increasing the available face time of production crews.

5) Installation of more diesel-powered equipment for carrying blasting supplies, tools, lubrication equipment, and general maintenance supplies.

The future trend will be toward conveyor belts for panel areas delivering their material to rail cars or mainline belt.

During the past year the potassium sulfate market has grown. **International** has increased production of this product to meet the demand.

by John Chandler

American Metals Co. Ltd.

Tri-State District

During 1956 the Tri-State district will mine about 3,844,000 tons of ore with a metallic recovery of 1.69 pct Zn and 0.62 pct Pb. Most of the production comes from mines operated by the **Eagle-Picher, American Zinc,** and **National Lead** companies, all of which are using diesel-powered equipment and trackless mining methods. Almost all of the ore is being concentrated in three large mills, the balance going to three smaller concentrating plants.

Potter-Sims Mines Inc. has reopened the **Sucker Flats** open pit mine near Webb City, Mo. About 300,000 yd of overburden have been stripped and mining was started in July. Average rate of production for the balance of the year was 1600 tpd.

Mining practices have not changed to any appreciable extent during the past year. Most of the drilling is being done with crawler and diesel-truck mounted jumbos using both the rigid boom and jib boom mountings with long sash machines. Jackleg machines are used to a minor extent, principally in areas inaccessible to jumbos. Standard high carbon steel rods are in general use with carbide insert bits. **Eagle-Picher Co.** has continued to develop and use high mast jumbos to mine roofs up to a height of 75 ft above the floor.

Most of the ore is being loaded with front-end loaders, crowding boom-type shovels, electric-powered crawler-mounted ramps and, to a lesser extent, with large crawler rocker shovels.

Mines with the greatest production are, in general, using various types of semi-trailer trucks with capacity up to 15 tons. About half the total production is being hauled with these units. For underground haulage **National Lead** has developed and is using 20-ton four wheel tractor trailer units with amazing success. These units can be used in areas of low backs as well as in standard height stoping. In the other mines, standard 8-ton dump trucks are being employed.

About 100 miles of primary underground haulage roads are being maintained using regular diesel-powered road grading equipment.

The ore occurs in bedded chert which breaks readily with excellent fragmentation, which does not require underground crushing. Almost all the ore is being handled by *can hoist;* about 56 can hoist shafts are in operation, only two shafts using skip hoists. It is interesting to note that an efficient can hoisting shaft can raise about 500 tons of ore per shift from a depth of about 300 ft.

Gooseneck two-wheel trailer, with hydraulic rear dump, is built without brakes or springs and rides on 12x24-in. tires.

A little more than half the ore is being transported to the mills by truck haulage, the balance being shipped over a standard gage railway in 80-ton gondolas. Approximately 60 pct of the total production is treated in heavy media separation plants in the process of milling. This makes a final coarse tailings from ⅜-in. to 1¼-in. size, which is sold for railroad and highway ballast and concrete aggregate. About 174,000 tons per month of this product is being produced. Standard jig mill and flotation practice is being followed to produce high-grade zinc and lead concentrates.

During the past year, long hole prospecting expanded considerably using sectional steel with 2⅜-in. and 2¾-in. carbide insert bits. This method of prospecting has largely replaced the use of churn drilling in close proximity to the mine workings. Lateral holes have been successfully drilled to a depth of 250 ft. The ratio of the amount of ore found to dollars spent on prospecting has been greatly increased by longhole prospecting.

Trackless equipment is especially adaptable to the flat-lying orebodies of the Tri-State lead and zinc district, where mine workings are 12 to 50 ft. These specially designed units can be used in areas of low backs as well as in standard height stoping.

by B. B. Greenlee

Colorado

Although no important new mines were put into production during the past year, development and activities of current operations increased. Colorado underground mining for the coming year is promising.

Climax Molybdenum's mine near Leadville—probably the world's largest underground mine—is a model of efficient and progressive mining practice. The company has invested heavily in research for new uses for its product and is rapidly diversifying its operations into oil, uranium, and other minerals. Demand for molybdenum has been good during the past year and the plant at Climax has been operating at peak production on a six-day week basis. Climax is producing 32,500 tpd—about half from the Phillipson level and the other half from the Storke level. Development has been accelerated on both levels, and production will be increased to 34,000 tpd in the near future. About 1700 men are employed at Climax, and manpower requirements will be stepped up in 1957.

Expansion of the Climax plant continued during 1956. A 13x12-ft ball mill unit was added to the primary grinding circuit to increase capacity from 3500 to 3800 tpd. An additional unit of the same size, now under construction, will be used to improve the overall grind in the primary concentration circuit. To provide increased water pumping capacity, a new pipeline is currently being installed from the company's Robinson Lake storage reservoir to a 2-million gal storage tank adjacent to the mill. Replacing a 20-in. line now in use, the new line will be 20,000 ft long and will elevate the water to 646 ft. The water system will then consist of the new 30-in. line and a 25-in. line. Added pumping capacity is to be installed during the coming year.

During 1956 **Telluride Mines Inc.** and **Tomboy Gold Mines Inc.** were liquidated into the parent **Idarado Co.**, thus creating the largest collection of mining properties in the history of the San Juan area. Company operations proceeded smoothly through the year. The expanded **Pandora** mill at Telluride was brought into production in January, and the consolidated operations for 1956 will produce more than 450,000 tons of lead-copper-zinc ore. On December 1 the famous **Red Mountain** mill was closed and all underground ores diverted to the Pandora, where milling will be scheduled at 40,000 tons per month. It is believed certain that the move will render possible the extraction of lower grade ores in future.

The New Jersey Zinc Co. Empire Zinc Division at Gilman, Colo., with the longest record of continuous operation for any important mine in the state, maintained steady production of zinc and other metals during the year, its 1200-ton mill operating a five-day week. Empire Zinc's operation is unique in that its mill and shops are underground.

During the past year **American Smelting & Refining Co.** and **Resurrection Mining Co.** will manage a joint venture to explore further and develop and exploit their respective properties in Leadville, Colo. A new surface plant has been installed at Asarco's **Irene** shaft which includes new hoist, compressors, change house, and auxiliary building. One unit of Resurrection's 800-ton mill has been rehabilitated and is operating at 400 tpd, milling lead-zinc-copper ores from the **Irene** shaft and **Julia Fisk** shaft in Iowa Gulch. A certain amount of lease and custom ore is being milled. With the resumption of operations under this joint venture it is hoped that mining activities in Leadville will continue for some years to come.

The historic **Camp Bird mine** near Ouray, for many years under lease to the **King Lease**, has been operated by the owners, **Camp Bird Ltd.**, since November 30, when the mill was shut down. During the past summer considerable diamond drilling was accomplished, and a large development program is under way. The Camp Bird mine has long been a steady producer of gold, lead, and zinc.

The **Rico-Argentine mine** at Rico, Colo., has continued to operate throughout the year, mining and milling some 130 tpd, producing zinc and, in lesser quantity, lead concentrates. During the year the company continued to operate its contact process sulfuric acid plant and is currently producing approximately 150 tons of sulfuric acid daily. Up to the present time mill tailings upgraded to 50 pct sulfur have been the source of material for the sulfuric acid plant. The company plans shortly to supplement the diminishing stockpile of tailings with pyrite ore from its underground operation and expects to construct a crushing plant to handle the 250 tpd of pyrite necessary for the sulfuric acid plant.

Emperius Mining Co. of Creede, Colo., completed and placed in operation a modern 150-ton selective flotation mill and a 1500-kva power plant in June of this year, to replace a mill and power plant of similar size destroyed by fire in August 1955. The company is now operating at plant capacity, producing an average of 300 tons each of lead and zinc concentrate per month. Concentrates also contain fairly high values in gold and silver. Underground mine operations continued without interruption during the mill construction period. Approximately 12 years of ore at present mill rate of operation has been blocked out and another 12 years of ore is in sight. The mine is fully mechanized with the latest mining machinery. Ore is transported from the several miles of underground working by four electric locomotives. About 80 men are employed by the combined mining and milling operations.

Asarco operated the **Keystone mine** near Cresta Butte, producing lead and zinc concentrates from its new mill.

During the first nine months of 1956 the Cripple Creek mining district some 70 miles southwest of Denver produced 37,895 oz of gold worth $1,326,-325.00, resulting from treatment of 89,528 tons of ore in the **Golden Cycle Carlton mill.** The mines contributing to this production are as follows: the **Ajax Group, Cresson Group, LeClair Group, United**

Gold Mines, Front Range Mines, El Paso Mines, Elkton Mining Co., and Mollis Kathleen Mining Co., the Ajax and Cresson Mines being the largest producers. The largest percentage of the ore is being produced by leasers.

A number of smaller operations have been active throughout the state during the past year. In the Silverton area the **Pride mine** was operated by **Barney Blackmore** and the **Osceola** by **Tech-Ser Mining Co.** Ores from these two operations are handled by the **Pride of the West mill,** which handles approximately 2500 tons of ore monthly, producing lead and zinc concentrates. The **Wellington mine** near Breckenridge has continued a steady producer of 500 to 600 tons of crude ore a month. Also of interest in this area is the **Minnie mine,** which is just getting into production. The **Buckskin Joe mine** near Fairplay has continued development work on a small scale. A small amount of activity continues in the Bonanza district a few miles south of Salida. The Montezuma district near Dillon, Colo., has a number of small operators producing ores, the principal one being the **Burke-Martin Co.,** which operates a small mill. In the Clear Creek area west of Denver many small mines have been active in the past year, most operators using the facilities of the **Front Range mill** at Dumont. At the present time the most important of these is the **Bald Eagle mine** up Virginia Canyon out of Idaho Springs. This mine was a steady shipper the past season and recent modernization has greatly increased production.

Uranium production from the Front Range increased during the past year, and there are now four small but substantial producers located in the Ralston Buttes district, Jefferson County. The most important of these mines is the **Schwartzwalder** property, operated by the **Denver-Golden Oil and Uranium Co.**

The recent Middle East crisis has again focused attention on the experimental oil-shale mine near Rifle, Colo., and may affect the Government's plan for its future development. More than a year ago, following two roof falls, Congress authorized the USBM to undertake development of a new and safer mining system. With the collaboration of engineers from industry a detailed mining research program was worked out, but the last Congress denied funds for putting it into effect. Thus on July 1, 1956, the Oil-Shale Experiment Station on Naval Oil-Shale Reserves was transferred from the USBM to the U. S. Navy. The USBM is currently acting as housekeeping and maintenance agency for the Navy, pending development of plans for the future use of the experimental mine.

by Philip Lindstrom and
James Greenslade

Uranium on the Colorado Plateau

Recent years have seen an impressive transition on the Colorado Plateau. The boom activities are becoming insignificant in relation to the orderly and efficient contributions to the nation's vital supply of atomic potential.

Ore recovery has been hindered by isolation and inaccessibility within the plateau's maze of canyons and washes. Gradual introduction of AEC access roads, improved lines of supply, power, and communication have enabled operators to achieve more efficient and profitable production.

Many well established mining companies have ventured into the uranium search. Uranium discoveries have also brought many new companies into the mining world. The most productive area to date has been the **Big Indian district** located between Moab and Monticello in southeastern Utah.

Standard Uranium Co. is producing at a daily rate of 500 tons. A Gismo was used to block out the orebody, which is mined by the room and pillar method with a crew of 35 to 40 men. Pillars are being mined at the present time. A dragline with a 35-ft boom and a ¾-yd bucket is being used to great advantage. Sublevel haulage with Granby dump cars is used.

Men are paid on a group bonus system per ton produced. A point system determines the payment to each man.

The **Mi Vida mine** of **Utex Uranium Co.** has maintained a monthly maximum production of 15,000 tons throughout the year. Mining practice includes room and pillar methods with trackless equipment for handling ore to the haulage level. Roof bolting is done from the platform of a diesel tractor which is raised and leveled by hydraulic cylinders.

A sublevel haulage tunnel and seven raises to the ore horizon, averaging 50 ft in vertical height, have just been completed. The Gismo system and equipment were used in driving the total distance of 2953 ft. An 11-ton trolley locomotive hauls ore to the storage bin, which will hold a full day's production. Development is now very close to the extremities of the ore body and there has been some experimental pillar removal.

Homestake Mining Co. continues operations at the **Little Beaver** and **LaSal** mines. The two mines are equipped with conventional underground equipment and together average an ore production of approximately 7500 tons monthly. *Under the bed* haulage systems are used.

During the year considerable exploration drifting and long hole drilling have been done. In the LaSal mine nearly 2 ft of exploration drilling has been done for each foot of development drifting. Long hole drilling has provided much information in the thick ore areas. Important savings were made when diesel and diesel-electric power were replaced by Utah Power and Light Co. installations.

Homestake's **North Alice** property, also in the Big Indian district, is being opened by means of a 2800-ft incline shaft. The project is under contract to **Centennial Development Co.** The usual bad bottom conditions along the **Chinle-Cutler** contact have been encountered and counteracted by installation of a long tie every 9 ft, bolted to the floor with short rock bolts through each end of the tie. Extensive roof bolting has been required, sometimes as high as three to four bolts per foot of advance. Average advances of 18 ft per day have been maintained, including rock bolting.

Hecla Mining Co. has developed the **Radon mine** in the Big Indian district for **Federal Uranium Corp.** under a profit sharing agreement. Current production approximates 230 tpd. Ore is produced through a 690-ft, three-compartment vertical shaft, the deepest on the Colorado Plateau. Conventional track mining equipment has been used so far.

Ground support has been a problem since development began. A longwall retreating mining method was planned to obtain the greatest possible extraction of ore. Becorit steel props on 4-ft centers will support the back along the longwall. The props are advanced and caving is allowed as mining progresses. The drifts reach the outer limits of the orebody from which mining is proceeding back to the shaft. Ore is moved by slushers down the longwall to the drifts and transported by Granby cars to ore raises and the sublevel haulage.

Continental Uranium Inc. has two properties in the production stage at the present time, both located on the Plateau southeast of Moab.

The Continental No. 1 mine produces 1500 to 1800 tons per month through an 11° incline, which intersects ore at 300 ft and then down-dips at 4° for about 700 ft. Trackless mining is used. Recently a 2½-ton diesel shuttle car has been added which can haul up the slope to supplement hoisting. An incentive bonus system based on the U_3O_8 pounds per manshift is shared equally by the entire crew.

Stripping of more than 2.5 million yd of overburden was completed in October 1956 at Continental's **Rattlesnake** property, where conventional open pit methods will be used. Selective mining of this deposit will produce approximately 200 tons of ore and 800 to 1000 tons of waste per day at present. There is an underground operation on this same property which has a 21° incline and uses track haulage under the ore, with open stoping over short raises.

The **Four Corners Exploration Co.** recently started production at its **Bachelor mine** in the Uravan mineral belt.

The rugged terrain south and west of Naturita, Colo., made drilling and road building costs very high. Drilling was discontinued as soon as enough ore was blocked out to pay for cost of the shaft. Additional exploration is contemplated by underground drifts and long hole drilling.

Mine depth at the shaft is 300 ft. The shaft is of crib-type construction, with two 4 ft 4 in. by 4 ft compartments. Mining is still in the semi-development stage and production is expected to increase to 400 to 500 tons per month by the end of the year. Variation in the elevations of individual orebodies has been one of the principal difficulties encountered so far.

Climax Uranium Co. has probably one of the most difficult mining problems on the Colorado Plateau. At the **Mineral Joe No. 1** shaft the mineable ore is confined between two large faults in a sheared zone, and ground support is difficult to achieve. Operators have found that timber cribs and stulls support the back sufficiently for stoping operations and have a decided advantage over roof bolting.

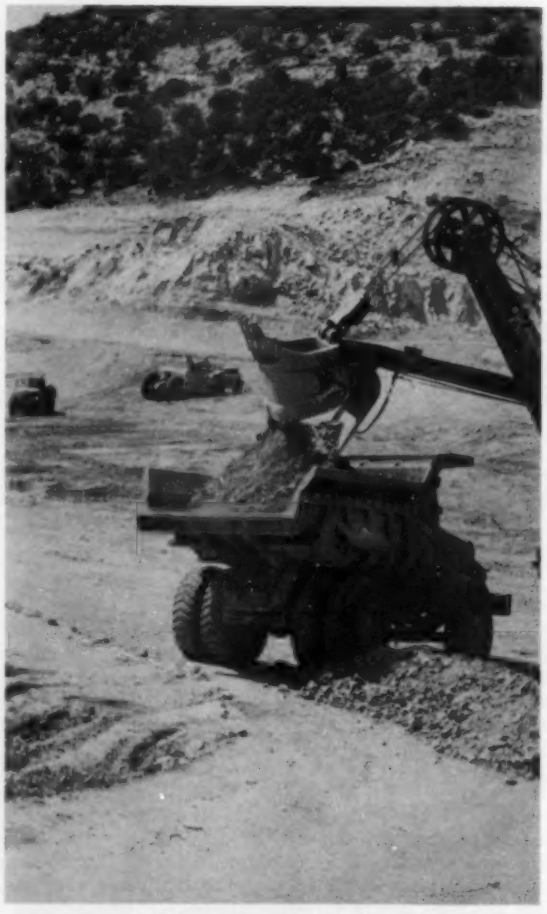
Uranium Prospectors Co. Ltd. is a wholly owned subsidiary of **Vitro Corp. of America,** which has several holding on the Plateau. The Uranium Prospectors property near Greenriver, Utah, is the only one in production stage at the present time.

Ore was located at 300-ft depth in the Morrison formation. A two-compartment shaft was sunk, 6x3-ft haulage drifts were driven to various small orebodies, and stoping subsequently began with slusher equipment. Production averages approximately 600 tons per month.

Deep well turbine pumps are used to dewater the mine. However, water itself is not the greatest problem. It was found that the solids carried into the water from the sandstone of the Morrison formation badly abraded the turbine blades of the pumps. It was necessary to build large settling ponds underground, settle the solids, and pump the clear water to the surface. This method is working satisfactorily.

The **Ambrosia Lake** area developed into the major ore find of the year. **Sabre-Piñon, Pacific Uranium, Kerr McGee, Rio de Oro, Holly Uranium, United Western Minerals Co.** and **Philips Petroleum** all have drilled sizable orebodies. To date only Rio de Oro has started underground production. Estimates of ore for this district vary from 12 to 30 million tons, with an average grade of $20.00. Several mills are being discussed with the AEC, the largest reported to be 6000 tpd.

Holly Uranium is operating the **Beacon Hill, Mesa Top,** and **Flat Top** mines in the Grants area, producing about 50 tpd from each. Ore grade averages between $10.00 and $20.00. Mining is done by scrapers.



Rear dump hauler used in open pit operation on the Colorado Plateau.

by Rollin Farmin
Day Mines Inc.

Washington Idaho Oregon California

Pend Oreille Mines & Metals Co., at Metaline Falls, Wash., is engaged in a development program that includes deepening its main, 15° inclined shaft about 2500 ft to a total of 6300 ft. Waste rock from sinking is loaded into skips by a crawler-mounted rocker shovel (Eimco 630), is hoisted to an underground crusher, and then elevated to surface via the permanent conveyor belt system of the shaft. The main ore belt will be extended to a total length of 5300 ft and an additional crusher station will be installed near its base.

Knob Hill Mines Inc., at Republic, Wash., has improved the cost of development raises on the vein (60° dip) and of subsequent stoping alongside by changing the type of raise employed. The former type was three compartments wide (chute-manway-chute). The new over-and-under, or slot-type raise, is comprised of a manway against the hanging wall over an untimbered chute that extends to the footwall. As the subsequent horizontal cut-and-fill stopes rise at each side of the slot raise, the horizontal timbers in the raise are removed and replaced with timbers designed to support the hydraulically placed sand that fills the stopes.

At Cobalt, Idaho, **Howe Sound's Calera mine** has been experimenting with slot stopes, oriented to rise diagonally up the rake of the orebody. Each slot is as deep as the ore extends and is three timber sets in length. When three successive three-set slots have been completed, they are cleaned down, laced and hydraulically filled with mill sands. The main haulage adit (8x8-ft cross section) is to be lengthened 2500 ft. For this tunneling job a newly designed whup d' whup train has been installed, made up of nine integrated cars of 125-cu ft capacity, each with a slusher hoist to spread the muck back along the length of the train. The first train of this type was used successfully last year by **San Francisco Chemical Co.** at Montpelier, Idaho.

Asarco's Page mine near Kellogg, Idaho, is deepening the main shaft, a 51° incline, from the 3070 to the 3400-ft level. Although it is a proved loader for vertical shafts, the Cryderman mucker being used faces a severe test at Page, where weak ground and abundant ground water make close timbering imperative. Also shafts of intermediate inclination are the most difficult for mechanical shoveling. Wall plates are bolted to the hanging wall, permitting delayed installation of divider timbers in the bottom three sets where the mucker operates. A bottom dump incline skip delivers the sinking waste to the pocket at 3070 station.

The **Bunker Hill Co.** deep level exploration of the **Crescent mine**, near Kellogg, Idaho, has involved deepening the internal shaft to 400 ft below sea level, followed by driving more than 8000 ft of crosscuts and drifts at the new bottom level. Ventilation of the new workings is a major problem because the headings are 5000 ft beneath the mountainous surface and 2½ miles from the source of fresh air. By use of a 200-hp motor blower, 9300 cfm of air is delivered through 20-in. diam Naylor spiralweld pipe to the working face at 64°F wet bulb temperature, although the rock temperature is 84°F. The ventilation fan compresses the air to 3.75 psi or 104-in. water pressure. The system has been an outstanding success and has permitted excellent progress in a difficult environment.

The **Galena (Vulcan) mine of Asarco** and **Day Mines** at Wallace, Idaho, has improved safety in development raises on undulating veins by attaching the small timber skip to a special wooden guide, replacing the former unguided slideway. Raise progress has improved since drilling has been done with lighter stopers, of 24-in. feed, with 1⅜-in. diam Carset drill bits. Main shaft signals from a moving cage to the hoistman are wholly reliable since adoption of a conductor-core type for hoisting cable. The insulated, three-conductor core also is utilized to transmit automatic signals to the hoistman when the doors of the bottom dump ore skips are fully opened and are completely closed, thus avoiding spillage in the shaft.

Lucky Friday Mining Co., Mullan, Idaho, completed raising and equipping a new three-compartment vertical shaft from a depth of 2300 ft, without interrupting ore production. After only a slight pause for conversion to the new facilities, the company has started sinking an additional 700 ft to reach the depth limit of the new hoisting equipment where they expect to prove a long life ahead for this relatively new producer of the Coeur d'Alene. A Cryderman shaft mucker is being used. The new shaft collar is reached by a 300-ft adit, through which supplies are delivered with a pneumatic-tired, forklift vehicle.

The **Silver Mountain** exploration project near Mullan, Idaho, managed by **Hecla Mining Co.**, is engaged in sinking a 2000-ft, three-compartment vertical shaft, from which exploratory crosscuts will be extended. Sinking is now nearly complete—excellent progress has been made using the Ridell shaft mucker. Equipment includes a front-end loader for all rock and materials transportation around the surface plant. Waste from the shaft is spilled directly to the ground, where it is picked up daily by the loader, moved to the rim of the widening dump area, and leveled. Shipments of timber, pipe, and rail are unloaded, stacked, and subsequently delivered to the shaft collar by forks attached to the loader. The machine shows additional versatility by removing the deep snow during winter months.

Production from underground metal mining in California shows a drop for 1956. Strikes in the Grass Valley area have idled these mines since July and plans to abandon the **North Star-Pennsylvania** and lower levels of the famous **Empire** are underway. At the **Idaho-Maryland** only limited production of tungsten is being accomplished. The Alleghany-Downieville district continues to produce gold in normal amounts with the **16-1** and **Best mines** leading the way. Tungsten production was affected by fulfillment of the government purchasing program. However, since an extension of this project by congress several small mines are being opened in the Taft-Kern County area. At Bishop, **Union Carbide's Pine mine** continues to produce, as do the **Surcease Mining Co. mine** at Atolia and the **Wah Chang Corp. mine** at Benton.

Uranium production from this state amounted to about 40 tons of commercial ore for the year. Some prospects have been explored.

With the price of copper rising, attempts were made to resume California's copper industry. Activity centers near Copperopolis, where the extension of the Pennsylvania orebody has developed ore in excess of 10 pct Cu. Mining at present is confined to the 400 and 500 levels. **Consolidated Nicholson mine** of British Columbia is considering rehabilitation of some copper mines in northern California.

Quicksilver supported by the government purchase plan shows new life. Production remained about the same. Closing of the **Somona mine** near Guerneville was necessary due to ore shortage. **Panco Mining Corp.** has started operation on its **Quicksilver** property in Marin County.

The quest for cinnabar ore during 1956 produced the most active news in Oregon in many years. **Shawano Development Corp.** completed a 100-ton mill for the **Bretz Mercury mine** in Malheur County. The **Black Butte** property was purchased by **Mercury & Chemical Corp.**, New York, and rehabilitation of both mine and plant is under way. Black Butte is Oregon's second largest producer of quicksilver.

Chrome mining in central and southwestern Oregon has employed approximately 100 men during the past year. Many small producers have benefited by the government purchase program—continuation of this program will undoubtedly intensify exploration. Commercial uranium to date has been confined to Lake County, where Thornburg's **Lake View Mining Co.** has made limited shipments of ore to the Vitro plant, Salt Lake City.

Activity in gold and base metals has intensified, and several major companies are exploring the older mining districts.

by John Bley and Koehler Stout

American Chrome Co., Nye, Mont.
Montana School of Mines, Butte, Mont.

Montana Utah Nevada

Underground mining operations in Montana during the past year have been limited to five major and seven minor producing companies.

The Anaconda Co. has the most outstanding program of expansion in the state. The company plans to expand its Butte operations by a $35 million program of mining and development. In addition to the **Berkeley** pit, now in production, this includes $20 million for the new **Ryan shaft** project. Completion of the Ryan shaft will facilitate mining from the lower levels. With the aid of a mechanical shaft mucker, Anaconda has also been sinking an additional 300 ft in the **Mt. Con** shaft.

Anaconda Chrome Co. has continued to produce chromite ore at a rate of 1000 tpd. This rate of production is adequately fulfilling requirements of the company's Government contract with General Services Administration. The company also has under way an extensive exploration and development program, which includes diamond drilling to delineate ore tonnage and grade below the present lowest level. A program to sink a three-compartment shaft 550 ft to develop this ore is in progress. A new research program has also been initiated for detailed study of the ferrochrome and byproducts possibilities of the low grade chromite ores of the **Stillwater complex.**

Montana Phosphate Co. of Garrison produced approximately 850 tpd of phosphate rock from the **Anderson mine,** and 380 tpd from the **Graveley mine.** Current production has been discontinued at the Graveley mine.

Relyea Phosphate mine near Garrison continued to produce crude phosphate rock at the rate of 3000 tons per month.

Victor Chemical Works maintained its production of phosphate rock from the **Maiden Rock** property at nearly the same rate as in the past.

Current production of the small operators throughout the state is as follows:

American Machine & Metals Co. of Philipsburg is producing up to 100 tpd of manganese ore from the **Trout-Algonquin** properties.

The **Jack Waite mine** of **American Smelting & Refining Co.** is producing 750 tons of lead-zinc concentrates per month.

The new mill of **Basin-Jib Gold Mines** is in operation on development ore from the **Jib mine.**

Golden Anchor Mining & Milling Co. near Elliston is producing 50 tpd of gold-lead-silver ore from the **Evening Star** and **Black Jack** mines.

A consistent lead producer since 1942, **Mauldin mine** near Dillon continued to operate in the Argenta district.

Northern Mining Co. has just completed a 100-ton mill and started operations on the **Hawkeye** gold property near Sandusky.

U. S. Gypsum continued to produce ore from its property at Heath.

by Miles P. Ramney

Utah Mining Assn., Salt Lake City, Utah

Utah–Nevada

Utah

Utah continued in 1956 to increase the volume and variety of its underground mining products. Although open pit operations in copper, iron, gypsum, sand and gravel, and evaporation harvesting of salt and potash provided the bulk of Utah's mineral tonnage, underground production was impressively substantial.

Lead-zinc production continued from the major operations, but a large number of the smaller and independent operators were unable to meet the high operating costs with the depressed prices received for metals. Lead-zinc prices for 1956—16¢ for lead and 13.5¢ for zinc—were approximately the same as 1947 to 1949 averages, whereas miners' wages have increased about 50 pct, along with substantial increases in supply and freight costs.

Among the major operators, **New Park Mining Co.** closed September 1 and reopened September 17 on a curtailed basis. Operations of **Chief Consolidated Mining Co.** and **Combined Metals Reduction Co.** were substantially reduced. **United Park City Mines Co.** is stressing exploration and development of the merged **Silver King** and **Park Utah Consolidated** properties, and **U. S. Smelting Refining & Mining Co.** is continuing near normal operations at its **Lark** and **Bingham** properties. Utah's 1956 production should be approximately the same as 1955.

Bear Creek Mining Co., Kennecott Copper's exploration subsidiary, has started a long range exploration project in the **East Tintic** mining district on about 10,000 acres of mining claims, included in agreements with six companies having holdings in that area. Both diamond drilling and underground explorations are planned.

Salt Lake Tungsten Co.'s addition of a refining unit to its mill to produce ammonium para-tungstate improved the company's position in the custom field.

Sun Uranium Co., Lucky Star Uranium Co., and **Baggs Uranium Co.** mined ore in the Newfoundland range near Groome, 80 miles west of Ogden, from an orebody reportedly containing 7500 tons valued at more than $1 million. **Sun Star Milling Co.,** affiliate of the above companies, purchased the **HM&S** mill in Salt Lake City to treat this and custom ore.

Utah Chrome Co. and **Comstock Uranium & Tungsten Co.** built a 100-ton flotation mill to treat ore from their **Pine Peak mine** 55 miles west of Delta.

At the **San Francisco Chemical Co.** phosphate rock mines in Rich County, a newly developed mucking and haulage mechanism, combined in one unit, reportedly speeded up broken rock movement and reduced operating costs. The rock is shipped to Western Phosphates, Inc. at Garfield, Utah, for treatment. Enlargement of this plant planned during the year will require stepped-up mine production.

San Francisco Chemical Co. reportedly took an option on some 3000 acres of phosphate rock in the Vernal, Utah, area and planned engineering studies preliminary to possible open pit operations. Phosphate reserves in the entire Vernal area are estimated as some 2.5 billion tons.

After narrow veins of outcropping orebodies have been depleted, these stulls provide wall support as the search continues underground.

American Gilsonite Co. is in the process of converting part of its underground mining operations to a hydraulic cutting, tramming, and hoisting system, involving cutting with water through nozzles at high pressure and pumping wet material to the surface. In another of its operations all mining is being done with a mechanical cutter, operating with sufficient water to move the broken material from the face to pump stations for pumping to the surface. These methods have been devised as an improvement on drilling, blasting, car tramming, and mechanical hoisting.

The same company has partially completed a 71-mile 6-in. pipeline from the mine at Bonanza, Utah, to a refinery near Grand Junction, Colo. At the starting end of the line a battery of outside packed plunger pumps, developing 2200 psi, will pump a prepared slurry through the line, which crosses a pass 3000 ft higher than the pumping plant.

Utah assumed leadership in 1955 uranium production and should be at or near the top in 1956, but New Mexico is threatening to take the lead.

The AEC reduced penalities on high-lime-content uranium ore sold to its Monticello buying station and mill. The shipper may elect no lime penalty, but in so doing must sacrifice pay for vanadium.

A number of *upgrading* mills were planned in various uranium producing areas.

Uranium Reduction Co.'s plant at Moab started operations late in 1956. **Hidden Splendor Mining Co.** purchased a 30 pct interest in this mill, thereby providing an outlet for its ore other than by building another mill. **National Lead Co.** took over operation of the government-owned mill at Monticello on April 1. **Texas Zinc Minerals Corp.** has started construction of a mill at Mexican Hat, Utah, particularly for treatment of ore from the **Happy Jack mine**, recently purchased by Texas Zinc. **Vitro Uranium** negotiated a 1.2 million expansion of its present Salt Lake City mill.

Nevada

Nevada's underground mining activity during 1956 was highlighted by strong activity in tungsten and mercury. Uranium mining and exploration continued on a relatively small scale. Lead-zinc operations were highlighted by new high grade ore discoveries in two mines, but the general level of operations was down owing to closing or reducing operations in others.

Eureka Corp. Ltd. at Eureka, Nev., and **Bristol Silver Mines Co.** near Pioche have had substantial production from new orebodies discovered during the year. **Federal Uranium Corp.** took over operation of the **Galena Hill mine**, 11 miles south of Reno. **American Zinc, Lead & Smelting Co.** and **Cyprus Mines Corp.** acquired substantial interests in the **Mount Wheeler White Pine County mine**, presently the subject of a major exploration program.

Combined Metals Reduction Co. is continuing mining and milling at its Pioche properties, but on a much reduced basis due to present unfavorable economies. Underground copper mining activity was confined to some exploratory work at the **Rio Tinto** copper mines at Mountain City, at the **Davis Canyon** copper property at the north end of the Diamond Range, Elko County, and the **L and H Mining Co.** property in the Battle Mountain Range of Lander County.

Completion of the 3-million unit tungsten program—several months before legislation setting up a new program was passed—caused shutdowns in most tungsten mines. Otherwise operations proceeded as follows:

Nevada Scheelite Corp. sank to the 400 level of its **Mineral County mine** and continued its milling of mine ore and old tailings.

Reserves of 200,000 tons were reported early in 1956 in a mine near Tonopah owned by the **American Duchess Uranium and Oil Co.** and the **Lutah Uranium and Oil Co.** Shipment of ore was planned to the **U. S. Vanadium Corp.** mill at Bishop.

Wah Chang Mining Corp. continued production of about 500 tpd at its **Lincoln County mine.**

Getchell Mines Inc. operated its mines and mills near Red House, Humboldt County, and planned addition of a pilot plant to investigate production of synthetic scheelite.

Nevada-Massachusetts Co. in Pushing County, **Gabbs Exploration Co.** in Nye County, and the **Minerva mine** in White Pine County were also substantial producers.

Minerals Engineering Co., Homestake Mining Co., David Sayre & Associates were prominent in the news regarding planned exploration of tungsten properties.

Activity in quicksilver mining increased during the year. The principal producer was the **Cordero Mining Co.** operation in northern Humboldt County. Others reported to be producing were:

Comstock Uranium and Oil Corp. and **Sam A. Arentz** in a joint venture on the Brentz property, northern Humboldt County.

White Caps Mining Co. at its **White Caps mine**, Nye County.

Belco Petroleum Corp. at its **Cahill mine** in Humboldt County.

C. C. Coppin and **G. J. Harrison** from the **Redbird mine** near Lovelock, Pushing County.

Walter Lewis property 50 miles south of Winnemucca in the Mt. Tobin area.

Development and construction of plant facilities that may have come into operation during the year were reported at:

The Kollsman Mineral & Chemical Corp. B & B mine, Esmeralda County.

The United Uranium Corp. McCoy mine, Lander County.

Nevada Mercury Corp.'s property near Lovelock, Nev., installed a 100-ton flotation mill, reportedly the first such mill in the state for mercury beneficiation.

Miller Basin Mining Co.'s shaft sinking on the Eureka group near Lovelock, Pushing County.

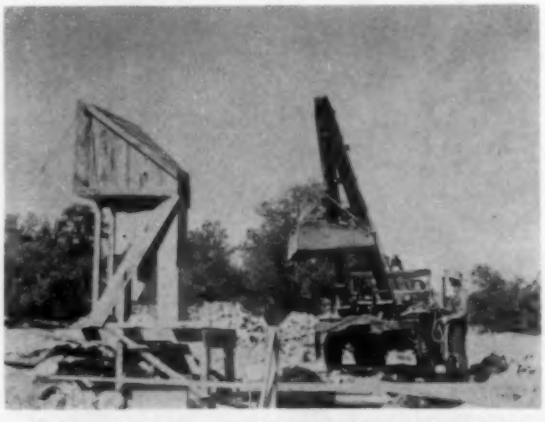
Exploration or planned exploration and reactivation of mines was reported by:

Mercury Corp. of America on properties in Pushing County.

Mullen-Buckley Uranium Corp. on Lincoln County properties.

Uranium Exploration & Copper Co., near Ione, Nye County.

Uranium production has been reported from the **Apex Uranium Co.** property near Austin, Lander County; the **Happy Joe mine** near Mountain City in Elko County; the **Black Bonanza Co.** property near Beatty, Nye County; and Gerald Hartley's property **(DeLong-Champs)** near Pyramid Lake, Wahoe County.



This wooden structure at Wedding Bell Mt. in San Miguel County, Colorado, is an air scoop facing the prevailing winds. Although not entirely satisfactory, it provides a pound of air pressure which clears out pockets of gas.

by John Chandler

American Metals Co. Ltd.

Illinois–Wisconsin Zinc District

Six mining companies are operating 10 mines in the Illinois-Wisconsin district. These mines are scattered over an area of about 1200 sq miles in the northwest corner of Illinois and the southwest corner of Wisconsin and are producing a total of 120,000 tons of ore per month which is being treated in seven different mills. About 90 pct of the total production comes from mines operated by the **Eagle-Picher, Tri-State Zinc,** and **American Zinc, Lead & Smelting** companies. Almost without exception, all of the operating companies employ trackless mining methods, using diesel and electric-powered equipment.

Most of the drilling is being done with crawler-type jumbos, using fixed boom and jib boom mountings with long sash machines. Where level floor conditions prevail, jib booms are mounted on diesel truck carriages. Jackleg machines are used in places inaccessible to jumbos. Most of the drilling is being done with standard high carbon steel rods with detachable throw-away bits. Tungsten carbide bits are used to a minor extent. One company is using 1-in. hex alloyed steel with integral tungsten carbide chisel bits. In general, the depth of holes varies from 9 to 12 ft.

Types of loading equipment vary from mine to mine. Usually about 48 pct of the production is handled with overhead loaders, 31 pct with full revolving diesel or electric shovels, 16 pct with end loaders and 5 pct with the Gismo loader. A new 1¾-yd rubber-tired end loader is presently being tried out in place of crawler equipment in one mine.

When hauling distance is not over a mile one way, most of the larger mines use dumptor and dump bed trucks. On longer hauls, 12 to 15-ton semi-trailer trucks are being used. One operator is using 15 tons Tournarockers, hauling ore from underground directly to the mill. The practice is now general to use adits or incline tunnels from surface to the underground workings where the depth of the orebody and topography are favorable. These inclines vary from 200 ft to as much as 2000 ft in length. More than half of all the production is now being trucked directly from underground operations to the mills by this method. In some instances, ore is being transferred underground from short haul units to transport units.

Underground crushing of coarse ore is being done in three of the larger mines and another is in the process of installation. This mine is now planning to belt convey ore from the crusher station to surface through an incline tunnel. Ore will be loaded and transported by Gismo to the crusher station at the foot of the incline. When the distance from loading faces to crusher station exceeds that for maximum efficiency, the ore will be hauled from the Gismo to the crusher station using Sanford Day Gismo loading cars.

by Wayne Dowdy

EIMCO Corp., Birmingham, Ala.

Southeastern U. S.

Tennessee Coal & Iron Division at Birmingham, Ala., began mechanization in 1951. Bulldozers of the D-4 size were purchased and equipped with electric motors and cable reels to perform grading. Later, diesel bulldozers of comparable size, with exhaust scrubbers, were purchased for this work. During 1956 two diesel front-end loaders with auxiliary bulldozer blades were added to the grading equipment. In addition to grading and material handling, their versatility is proving useful in other applications.

Roof bolting at TCI ore mines has been performed by a three-man crew in each working place. Their work has been done with stoper drills and impact wrenches operating from an elevating platform mounted on air-powered carriages. During 1956 TCI ore mines installed two experimental roof bolting machines. These air-trammed machines have a drifter drill mounted vertically upon a hydraulic operated arm. There is an independent elevating platform for the operator. The drills have stop-rotation for driving of bolts. The work is performed by a two-man crew.

In the ore mines of **Red Mountain,** shuttle cars of both electric and diesel-electric type have been in use. Because of adverse steep grades, ten shuttle cars of a new design have replaced a similar number of the existing cars during 1956. For better maneuverability the new cars have four-wheel steering and four-wheel drive. In addition, the motors have been changed from two 10-hp 1-hr rating, to two 20-hp continuous rating. Improved brakes of the airplane type design have been added. The cars, in general, have been strengthened for continuous duty in steep working places.

Prior to 1954 practically all the iron ore mined by **Woodward Iron Co.** was loaded with drag scrapers (slushers) from stopes or with track mounted loaders in development work. Since that time the trend has been to off-track equipment until today about 50 pct of the ore comes from stopes in areas that were originally developed for stope mining.

Stopes are driven 200 ft deep, either as single or double wing. Loading is done with drag scrapers directly into cars by means of an inclined ramp in the stope neck.

In off-track sections an average of six places, 20 ft wide, are driven on 70-ft centers with crosscuts every 70 ft. The number of places driven depends principally on the thickness of the ore, the object being to have enough ore broken to keep the loader busy at all times. Two shuttle cars serve each loader. Each car has a maximum travel distance from the ramp of about 500 ft.

Drilling in the off-track sections is done with two drillmobiles carrying two drills each, using 1¼-in. steel with carset bits.

USBM-approved diesel engine dozers are used extensively for maintaining roads, cleaning up, and gathering the broken ore to the face after blasting. Woodward was the first in the district to use the approved units. Auxiliary fans of 3000-cfm capacity are suspended from the roof with roof bolts. Metal tubing carries the air to the faces. The air and water lines are hung from the roof, also, to keep open the areas in which the mobile equipment travels.

Rock bolting is used for roof support throughout the mine.

At Copperhill, Tenn., development of the Calloway orebody of the **Tennessee Copper Co.** includes extension of the 1400-ft underground circular shaft to surface. This 700-ft extension is being advanced by driving a 6-ft circular raise along a 4-in. borehole with subsequent reaming to shaft size. Stope and haulage development in anticipation of production by 1959 is being advanced from the underground shaft.

Stoping techniques are trending toward the use of 3-in. drifters with ⅞-in. sectional rods for blasthole drilling in holes to 70 ft deep. EX blasthole drilling by diamond drills still is used in 75 pct of the stoping, but improvements in carbide bits and sectional steels indicate a trend in that direction. There is a change away from large tonnage ring drilled stope blasts to smaller blasts of 300 to 500 tons to prevent storage of muck in stopes and minimize blasting concussion.

Methods using either scraper loading into chutes or direct to cars are employed in loading; 25 to 125-hp electric slushers are in use. The tendency toward handling coarser muck to underground crushers has improved loading efficiencies.

Battery locomotive haulage is being continued and side dump cars in 8 or 10-ton capacities with down folding doors are favored. This type of dumping seems to improve car cleaning.

Use of abrasion-resisting plate steels is replacing formerly used manganese steel castings as chute liners and other wear surfaces.

In 1954 diamond drilling by the **Appalachian Sulphides Inc.** of Jefferson, N. C., located the extension of the **Ore Knob** copper vein. This original vein produced over 200,000 tons during the period from 1873 to 1883. The deposit is a steeply dipping chalcopyrite-pyrrhotite vein averaging 14 ft wide. During 1955-1956, a three-compartment vertical shaft was sunk to 1037 ft by **Cown & Co.,** shaft contractors of Birmingham, Ala. The mine is now being developed on three levels—the 560, 700 and 840—and a flotation plant with capacity of 700 tpd is under construction.

The ore will be mined by shrinkage stoping and sublevel benching, using Eimco 21 loaders at the drawpoints and Mancha 1½-ton locomotives for haulage. Mine development and plant construction are being done by Appalachian Sulphides, and production should start early in the spring of 1957.

Tungsten Mining Corp. at Henderson, N. C., has completed the shaft level stations, ore and waste pockets and ore transfer raises down to the 1500 level of their two vertical shafts. Development work of crosscutting to the ore zone has started on the 1500 level. Limited development done on the 1300

level has revealed good orebodies. A new ore vein was encountered in one of the 1500 level crosscuts, but this has not as yet been developed to prove its size.

During 1956 the **New Jersey Zinc Co.** completed development of the **Jefferson City mine** and continued the development of the Flat Gap mine. The Jefferson City mine, located approximately one mile south of Jefferson City, Tenn., reached a production stage in October 1956. Development and construction work at the **Flat Gap mine** in Hancock County near Treadway is expected to be completed in 1957. Present plans are to place the mine on a production basis during the fourth quarter of 1957.

The Jefferson City mine has been developed by two vertical shafts 3425 ft apart. The hoisting shaft is a seven-compartment rectangular shaft 13x19 ft in dimension. The cage compartment is 8x12 ft to permit access of large equipment underground. The shaft also contains two skip compartments, counterweight compartment, pipe compartment, electrical compartment, and a manway. The shaft is 1302 ft deep with six mining levels at approximately 50-ft intervals beginning at 938 ft. Facilities are provided below the sixth mining level for primary crushing of the ore and for automatic skip loading.

The hoisting shaft is connected underground with the ventilation shaft by an 8x10-ft drift 4600 ft in length on the first mining level at a depth of 938 ft below the collar of the hoisting shaft. The ventilation shaft is a 12-ft diam circular shaft sunk to the depth of 1217 ft and contains a ventilation and manway compartment. An exhaust fan of 60,000-cfm capacity is located at the collar of this shaft.

Surface mine facilities are provided in a U-shaped building constructed near the collar of the hoisting shaft. The building contains the offices, warehouse, shops, hoist room, change room, chemical laboratory, bulk storage space, and heating plant. It also contains the main electric switch-gear from which all electric power lines are distributed and controlled.

Hoisting equipment consists of a double drum Nordberg ore hoist and a single drum Nordberg man and material hoist. Hoist controls are manufactured by the Electric Controller & Manufacturing Co.

A flotation mill with 1000-tpd crude ore capacity has been constructed near the collar of the hoisting shaft. The ore is crushed to —4-in. size underground, and hoisted in 5-ton overturning skips which dump into a surge bin feeding to a belt conveyor for transportation to a 1200-ton mill storage tank.

The ore deposit at the Jefferson City mine occurs in the Kingsport member of the Knox dolomite. The formation dip is gentle varying from 7° to 10°. Mining levels are at approximately 50-ft intervals vertically, and the levels are from 400 to 500 ft apart horizontally.

Ore is broken in the stopes by three-drill tractor-mounted drill jumbos, and by air leg drills. Ore is loaded by the *Gismo*, a self-loading transport powered by a diesel tractor. Capacity of the Gismo is about 5 tons. A limiting feature of the Gismo is that it cannot load direct into cars. As a result, ore loading preparatory to Gismo mining is accomplished by track-mounted Eimco 21 shovels and by tractor-mounted Eimco 630 shovels.

Use of the Gismo for loading permits trackless mining in the stopes. The main line haulage is in 4-ton Granby-type cars on track of 30-in. gage. Tramming is done with 7½-ton Greensburg storage battery locomotives. The ore is dumped into an ore pass that feeds to a primary crusher underground.

The **Flat Gap mine** is being developed by the sinking of a hoisting shaft, a ventilation shaft, and a service incline on a —10 pct slope.

The seven-compartment rectangular hoisting shaft, which is 13 ft 7 in. by 14 ft 7 in., contains two skip cages, counterweight, pipe, electrical, and manway compartments. The shaft, which reached the depth of 650 ft in October 1956, is to be sunk to 885 ft. Four main haulage levels are to be established at depths of 350, 500, 650, and 750 ft. Below the bottom level, facilities are to be provided for primary crushing of the ore and for automatic skip loading.

The ventilation shaft is to be a 12-ft diam circular shaft containing ventilation and manway compartments. It is to be sunk to the depth of 275 ft and connected by a drift from the first level at the hoisting shaft.

A 14x14-ft service incline is being driven on a —10 pct slope a distance of 3900 ft to connect with the 350-ft level at the hoisting shaft. As of October 1956 the incline had advanced 2300 ft from the portal. A means of access for large diesel-powered mining equipment, the incline also is being driven in the ore horizon for the purpose of developing stoping areas.

Construction of the surface plant and administration building is now in progress. Nearly identical to that at the Jefferson City mine, the building is a U-shaped structure near the collar of the hoisting shaft. It will contain offices, warehouse, shops, hoist room, change room, bulk storage, and heating plant. The main electrical switch-gear will be located in the hoist room.

Hoisting equipment will consist of a double drum Nordberg ore hoist and a single drum Nordberg man and material hoist. Hoists will be equipped with controls manufactured by Electric Controller & Manufacturing Co. Automatic operation of the skip hoist is planned.

A flotation mill with crude ore capacity of 2000 tpd is under construction near the collar of the hoisting shaft. The mill consists of two 1000-ton units, each almost identical in design with that of the 1000-ton mill at the Jefferson City mine.

The ore deposit at the Flat Gap mine occurs in the Kingsport member of the Knox dolomite. The formation has an average dip of about 37°. Mining levels are at 150-ft intervals except for the fourth level, which is 100 ft vertically below the third.

Present mining plans provide for breaking the ore by three and four-drill tractor-mounted drill jumbos. Ore is to be loaded by diesel-powered shovels into 8 and 10-ton trucks. These trucks will transport the ore to the ore pass, which feeds through a primary crusher underground into the skip pocket.

Development of the stoping operation required driving 14x14-ft drifts on a +10 pct grade along the footwall of the ore zone. From this 10 pct slope, horizontal slopes will be developed by slabbing to the hanging wall of the ore and advancing along the strike of the ore zone. Since much of the tonnage occurs as linear, pencil-type strike ore zones, it will be possible to do much of the incline drift development in ore. In areas where the major axis of the ore zone is not closely parallel to formation, strike modifications of the proposed mining plans will be

made as indicated by the geometry of the ore occurrence.

American Zinc's newest producer in this area is the **Young mine**, about 8 miles east of Mascot, which has been developed for the Gismo method of mining and is presently producing 1000 tpd.

The **Coy mine**, just east of Jefferson City, is being developed, and is scheduled to be brought into production during the first quarter of 1957.

The No. 2 mine at **Mascot, North Friends Station**, and **Grasselli** mine in Jefferson County are active, and production from these older mines is normal.

The two new mines will be fully mechanized. Some changes are being made in milling operations to improve metallurgical results and to accommodate larger tonnages.

The company has just completed a DMEA project known as the **Southwest New Market area** in Tennessee. Drilling here has been most satisfactory in every respect. A rough calculation of the tons of crude zinc ore indicated by this drilling is about 35 million tons, in which there will be approximately 2 million tons of 60 pct zinc concentrates. This tonnage exceeds the tonnage mined from all the company's Tennessee properties since operations began in 1914.

A new contract with the DMEA has just been concluded on an 1850-acre area known as the **Strawberry Plains area**, which lies across the Holston River to the east of the Mascot properties. This contract covers approximately 335,000 ft of diamond drilling and must be completed by Sept. 1, 1958.

by Severn Brown

St. Joseph Lead Co., Balmat, N. Y.

Northeastern U. S.

The talc industry of upstate New York enjoyed a very good year in response to the high demand from the paint and ceramic wall tile industries. Both **International Talc Co.** and **Gouverneur Talc Co.** have increased capacity. The latter is now handling all ore through the 24x36-in. jaw crusher on the 700-ft level. Provision is being made on the 700 level to load ore, with mucking machines, at drawpoints. Open stope methods are used to mine the talc ore from two orebodies which dip at an angle of about 45°. Underground shop, supply room, and magazine were also constructed during the year. In the mill a new 10-ft by 66-in. Hardinge mill, with slow speed synchronous motor drive, was installed. The newest entrant among the talc mines is the **Reynolds Talc Co.** at Edwards. An adit has been driven at the elevation of the mill to connect into the open pit, and the original mill is being revamped.

In New England, talc is production by the **Eastern Magnesia Talc Co., Inc.**, with headquarters in Burlington, Vt. The company's **Johnson, Vt.**, operation is a shaft mine producing about 200 tpd, with a mill incorporating a unique flotation system. The 100-tpd mine and mill at Waterbury turn out both finely ground powder and talc crayons used by steel workers. Newest addition to Eastern Magnesia Talc's family of properties is the **Gassetts, Vt.**, plant where foliated talc will be produced to supply the roofing trade. The ore will be trucked from a quarry located in Hammondsville, Vt.

During 1956 all three Republic Steel mines of the Port Henry district, Mineville, N. Y.—namely, **Old Bed, Harmony**, and **Fisher Hill**—have operated at capacity. The Fisher Hill mine produces both magnetic and nonmagnetic iron ore which is beneficiated in a concentrator, using both tables and magnetic separators. The other two mines produce magnetite ore, some shipped directly as lump ore and the rest concentrated by magnetic methods. Most of the concentrates are sintered at a two-strand Dwight-Lloyd sinter plant, which has a capacity of 3000 tpd.

Pelletizing experiments are being carried on and a pilot plant for pellet production will be in operation in the near future.

The Mineville orebodies range from low grade disseminated magnetite in a granitic gneiss to very rich and extensive concentrations of magnetite also related to the granitic gneiss, both following the intensely folded rock structures of the area. These folds have pitched generally to the southwest at an average of −25°. Mining is complicated by the irregular nature of the folding as well as by post ore faulting. Prospecting and development shows the ore to reach vertical depths of over 3500 ft, which makes an inclined depth from the outcrop some 8000 ft.

Zinc production from the **Edwards** and **Balmat** mines of **St. Joseph Lead Co.** continued at an even keel. The circular, concrete-lined drift was completed through the water-saturated gypsum-bearing ground in the 900 level haulage drift joining the No. 2 and No. 3 mines, and a start was made on deepening the No. 2 shaft. Prospecting by surface drilling was resumed on the Balmat property.

At the **Elizabeth mine** of **Appalachian Sulphides Inc.**—formerly the Vermont Copper Co.—at South Strafford, Vt., the year's production rate was the normal 24,000 tons per month of 1½ pct copper ore. Both copper and pyrrhotite concentrates are made on the property, the pyrrhotite being shipped to a paper company for sulfuric acid manufacture. The only innovation of any portent was the use of the Eimco 630 electric mucking machine, which proved very effective in driving down 12½° inclines. At this angle the incline could be mucked without the use of a hoist on the mucker and without modification of the standard equipment. An airborne geophysical program over the entire area has shown a number of anomalies that will be checked.

by John Wilson

U. S. Gypsum Co., Placterco, Va.

Nonmetallic Minerals

Industry in 1956 has enjoyed one of its greatest years in history. With production at peak levels, demand for industrial minerals has stepped up tonnages to an all-time high.

The construction industry, which probably consumes the lion's share of nonmetallic minerals, is keeping pace with the rest. Outlays for new construction reached $44.4 billion in 1956, 4 pct above last year's record of $43 billion. This gain is directly reflected in utilities, private industrial building, and highways. The number of new housing starts is declining.

Last year's production indicates the magnitude of the cement and aggregate industries. Cement was 296,829,000 bbl, with a total value of $848 million. Added to this, there were 316 million tons of sand and gravel. Total value of all nonmetallics produced during the year was somewhat more than $2.8 billion. If all predictions hold true, these figures will be dwarfed in the immediate years to come.

It is estimated that during the 13 years of the huge highway program at least 37 million bbl of cement and 175 million tons of aggregate will be added annually to normal demands.

Asbestos: Having accounted for two thirds of the value of nonmetallics produced in Canada in 1955, asbestos appears to have had another profitable year.

More details have been announced as **American Smelting & Refining Co.**, through its subsidiary, **Lake Asbestos of Canada Ltd.**, continues with its mammoth mining project at Black Lake in Quebec. In preparation for eventual open pit mining, Asarco must drain and dredge the waters of Black Lake to reach the asbestos orebodies some 70 to 200 ft below. It is expected that the $32 million to develop the mine and another $9 million for the surface plant will be spent before production starts in 1958. The mill will have a capacity of 5000 tons of ore per day, producing approximately 100,000 tons of asbestos fiber annually.

Borax: Pacific Coast Borax Co. has commenced an $18 million development program at Boron, San Bernardino County, Calif. In January work got under way on stripping of overburden to convert the underground operation to an open pit. The project, expected to be completed next year, includes construction of new refining and concentrating plants.

Cement: About 350 million bbl of cement were manufactured in 1956 compared with 300 million lb for 1955. This means that almost 105 million tons of raw materials were mined and quarried, making Portland cement one of the nation's biggest mining ventures. Even so, supply cannot keep up with demand, as imports have jumped sharply, exceeding the record of 4½ million for 1955.

Fluorspar: The government has announced plans to stockpile 250,000 tons of domestic acid-grade and 250,000 tons of metallurgical-grade fluorspar over a 2½-year period. This is expected to improve the domestic market situation, which has been seriously affected by Mexican imports. Many mines in the Illinois-Kentucky district have been idle in recent months, since operators have been unable to meet import competition.

Gypsum: Gypsum, being so closely related to the building industry, has seriously felt the decline in new homebuilding. This decline is expected to be greater than previously anticipated because funds for long-term, low downpayment mortgages at low interest rates have remained relatively scarce. The general tightening of credit has cast a shadow on the future of residential construction.

Although as a result sales are considerably off in the third quarter of 1956, as compared to the third quarter of 1955, advance estimates indicate that 1956 production will come fairly close to the 1955 record figures, which show that total consumption of domestic and imported crude gypsum was more than 14.5 million tons, according to the USBM.

National Gypsum has announced plans to develop a new deposit in northern Michigan near Lake Huron which is estimated to contain 60 million tons. This mine, which will cost about $6 million to develop, will supply new plants to be built in the

Equipped with a Link Belt TF loader, this Caterpillar diesel D4 tractor digs into limestone in underground quarrying operations of the Black White Limestone Co. near Quincy, Ill.

Great Lakes region. At the company's new Shoals, Ind., mine gypsum is transported by belt conveyor up the 2000-ft incline. Present capacity of the conveyor belt is 240 tph. This will eventually be increased to 350 tph. **Blue Diamond Gypsum Corp.** at its operation near Arden, Nev., is successfully using an aerial tramway to bring rock from its quarry and crushing plant down a mountain to the mill and board plant.

From Mexico comes word of a huge new find by **U. S. Gypsum** in the state of San Luis Potosi. With 300 million tons of commercial gypsum already blocked out, U. S. Gypsum is reported to be going ahead with plans for development—both at the desert site and at the Tampico docks. Initial production will be approximately 30,000 tons per month and should begin late in 1957, through their Mexican associate Yeso Mexicano.

Mica: The government has announced two new policies that should help the domestic mica mining industry. First, the buying program has been extended another five years and second, the prices paid to the miners for mica brought to any of the government purchasing depots has been increased. This is stimulating exploration as well as reactivating nonproducers.

Nephaline Syenite: A growing demand for nephaline syenite has focused attention on the **International Minerals & Chemical Corp.** new 300-tpd operation at **Blue Mountain,** north of Havelock, Ont. This interesting and extensive deposit is the largest and purest known to exist and the only one being worked on a large scale. Although production has been coming from this deposit since 1935, the entry of International Minerals & Chemical Corp. into the field of operations early in 1956 sharply increased output in this area. This igneous rock, somewhat resembling granite in texture, hardness, and general appearance, is principally used in the glass and ceramic industries.

Three quarry faces are being developed across the deposit, which has a light overburden. An underground quarry is planned for winter operations.

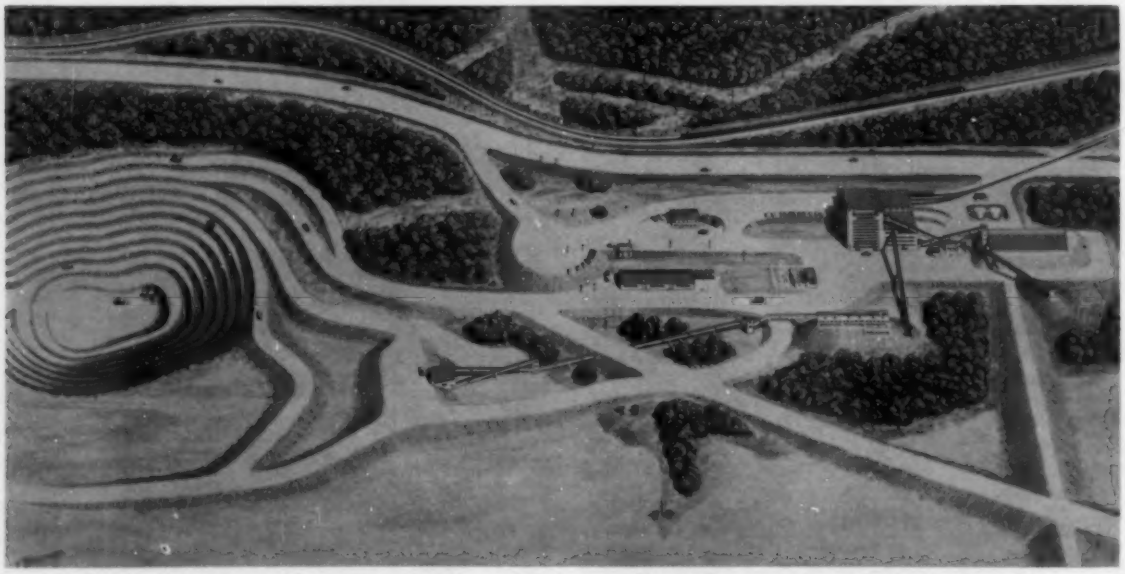
Perlite: The expanded product of this nonmetallic mineral is fast becoming an important aggregate in both plastering and concrete industries. Production in 1956 reached 250,000 tons, an increase of almost 14 pct over 1955. Expanded perlite now accounts for about 40 pct of the entire plaster aggregate market.

Phosphate: This important fertilizer industry has a new producer in the **J. R. Simplot Co. Centennial mine** near Monida, Mont. Thirty million tons of acid-grade ore reserves have been established by drilling. Plans call for 5 million tons of this to be mined by open pit. The remaining 25 million tons will be mined from what will be one of the largest underground phosphate mines in the West.

Potash: The **Potash Co. of America** and the **Continental Potash Corp.** have announced plans to start mining in Saskatchewan's huge 100-billion ton potash belt. Both companies plan to spend $20 million each in creating what will become a $10 million per year industry by 1958. This is Canada's only known commercial potash deposit.

Salt: In its mine at **Week's Island, La., Morton Salt Co.** is now using crawler-mounted, four-machine jumbos, self-elevating, to drill the entire 25-ft high face. Kennametal FDL 1⅝-in. drill bits are used with 1½-in. augers and Scranton drills to drill an average of 120 holes, 8 to 10 ft deep, per 50-ft wide face. Two-man crews reportedly drill 1½ faces per shift, including moving time, in tough but not extremely hard salt dome.

Sulfur: Recently **Freeport Sulfur Co.** announced plans to start mining the first completely off-shore sulfur deposit in history. This deposit, discovered by **Humble Oil & Refining Co.,** is located in 45 ft of water, six miles from the nearest land, off the coast of Louisiana. Under the contract signed by the two companies, Freeport will design, install, and operate the Frasch plant and split the net profits, after Federal royalties, with Humble. The sulfur is to be pumped 1700 ft to the surface, then into insulated barges. In the molten state it will be moved to Port Sulphur.



Architect's plan of the new asbestos fiber mill at Black Lake, Que., now being constructed by Lake Asbestos of Quebec Ltd., a subsidiary of ASARCO. Initial benching is under way to reach deposits uncovered by dredging and draining the lake. Proved reserves can support production of 100,000 annual tons of high grade fiber for more than 40 years.

by C. Mamen

Editor, Canadian Mining Journal

Eastern Canada

Ontario

Without a doubt the most spectacular achievements in the province have been in the new uranium industry, which has sprung up almost overnight in the **Algoma** and **Bancroft** districts.

Eight companies in the Algoma district, holding the world's largest known deposits of uranium, will provide more than two thirds of the approximate $1.5 billion worth so far contracted for in Canada. The combined daily tonnage of ore expected to be handled by these companies is 34,000 tons. **Pronto**'s 1200-ton operation started production in August 1955 and was followed this year by **Algom**'s two 3000-ton operations—the **Quirke Lake** plant in September and the **Lake Nordic** plant in December. Nearing completion and scheduled to start tuning up in January 1957 is **Consolidated Denison** with the world's largest single mill treating only uranium ore and having a capacity of 5700 tpd. **Can Met**, controlled by the same interests as Consolidated Denison, expects to be in operation in May 1957 at 2500 tpd. The largest contract held by a single company was given to **Northspan** at $275 million. This company was formed by the merger of **Spanish American, Lake Nordic**, and **Panel** and is providing a total of 9000 tpd of milling capacity to commence by the fall of 1957. The three remaining companies, all holding large sales contracts and working towards production, are **Stanrock** at 3300 tons, and **Milliken Lake** and **Stanleigh** at 3000 tons each.

In the Sudbury Basin, **International Nickel Co. of Canada** mined some 15 million tons of nickel copper ore per year, 85 pct from underground mines, and **Falconbridge** more than 1½ million tons. These two companies are cooperating on the extraction of a block of ore lying astride the common border between the **Fecunis Lake** property and the **Levack mine.** The first shipment of iron pellets was made from the new pyrrhotite plant of Inco in February, marking the recovery of yet another byproduct as well as increasing the capacity of the entire plant by 1000 tpd.

Also in the Sudbury area, **Nickel Rim** stepped up daily production from 750 to 1000 tons during the year. **Arcadia Nickel Corp.** is planning erection of a 1000-ton nickel-copper concentrator to treat ores from its **Worthington Offsets** mines under development.

Several other nickel-copper projects are developing into producers. The **Gordon Lake** property of **Eastern Mining & Smelting Corp.** anticipates a 1000-tpd operation. **Temagami Mining**, now shipping direct smelting copper ore, has also outlined large tonnages of lower grade nickel-copper-cobalt ore. **Stratmat** has proposed a concentrator and mining operation as well as a smelter near Fort Francis.

Consolidated Bi-Ore Mines in the Blind River district started a unique operation during the summer by running development ore from adit headings through a furnace to produce a 30 to 35 pct copper matte. **Coldstream Copper Mines** in the Kashabowie district is preparing a mine and concentrator for production in 1957 at 1000 tpd. **Consolidated Sudbury Basin Mines** is developing two copper lead-zinc-silver orebodies and started construction of a

Shaft No. 1 at the Stanleigh Uranium operation near Elliot Lake, Ontario. This shaft has now reached 1700 ft. Stanleigh is also drilling on the western part of its property, where there is indication of a second orebody.

Stanleigh Uranium Shaft No. 2 has been sunk to 1400 ft. Evenutally 800 men will be working on the property during the building period, 400 permanently. A townsite of 300 houses will be built at Elliot Lake.

mill of 3000-ton capacity for 1958, with initial rate of 1000 tons by 1957. In the Manitouwadge area, **Geco**'s 3300 tons and **Wilroy**'s 750-ton copper-zinc operations are approaching production stages.

Ontario's gold mining industry managed to maintain production despite growing hardships. Only one mine closed during the year—the **Starrett-Olson** in the Red Lake Camp failed to outline further ore. A considerable amount of shaft sinking was done reflecting belief in some quarters that the price of gold must eventually go up. This includes a 1000-ft internal shaft at **Wright Hargreaves**, which will bottom at 7950 ft and provide five more levels. **McIntyre Porcupine** went down to 7000 ft with an internal shaft collared at the 3750 level. **Delnite** deepened its shaft to 4875 ft to prepare three more levels. **Madsen Red Lake** is doubling the size of the production shaft in a unique operation designed to minimize loss of production time. This involved driving a raise alongside the shaft from the 2900-ft level to surface and then slashing into the raise. The shaft will also be deepened to 5000 ft below surface. **Renabie Mines** is deepening its shaft to 2200 ft from the previous 1450-ft bottom.

Ontario's growing iron ore industry headed for record production in 1956. **Inco** joined the ranks of the producers by virtue of its pyrrhotite plant having an initial capacity of 250,000 tons a year, with an ultimate capacity of 1 million tons grading 65 pct iron.

The **Helen mine** of **Algoma Ore Properties** mines 6000 tons of siderite ore per day by sublevel blasthole stoping method and is currently developing a new block of ore below the previous workings. Hoisting of ore will be by inclined aerial tramline, whereas ore from the upper blocks is handled by belt conveyors. **Steep Rock Iron Mines** commenced production from the **Errington** underground mine. Extraction here is by block caving and capacity of the mine will be 1.5 million tons per year by 1958. A larger production shaft was also started on the company's **Hogarth mine**, the eventual capacity of which will be 3 million tons.

Production from the cobalt-silver mines of Cobalt was hampered by strikes and a fire which destroyed the main mill of **Cobalt Consolidated**, the biggest producer. **Langis Silver & Cobalt** started production at its 75-ton mill and resumed milling at the **Castle Tretheway**, which was shut down during the winter.

The **Ojibway mine** of **Canadian Rock Salt Co.** carried out its first full year of room and pillar trackless operation since starting in August 1955. Daily production is 4000 tons on a one-shift basis. Developments leading to possible additional producers of rock salt in the province was the announced start of work on a new mine and plant at Goderich by **Dominion Tar & Chemicals Co.**, estimated to cost $6 million, and the acquisition by **Midrim Mining Co.** of salt beds near London, where drilling was carried out prior to sinking a shaft to a depth of 1750 ft.

Underground mine development was carried out at the **Munro mine** of **Canadian Johns Manville** at Matheson in preparation for production by 1958 to replace open pit operations.

Ontario expects to have its first lithium producer in 1958—**Nama Creek Mines** in the Beardmore district started sinking a production shaft and surface plant construction for a 1000-ton operation.

Gross output of the mines and smelters of Quebec is expected to exceed $400 million for 1956.

Quebec

Asbestos from the Eastern Townships continues to be the backbone of the industry, accounting for 25 pct of the total value of all minerals produced. The world's largest asbestos mine and mill of Canadian Johns Manville at Asbestos continued to develop the Jeffrey underground mine for the next lift of block-caving. No sooner was the new mill completed than plans were announced that capacity will be raised beyond the 625,000 tons of fiber which is the current rate.

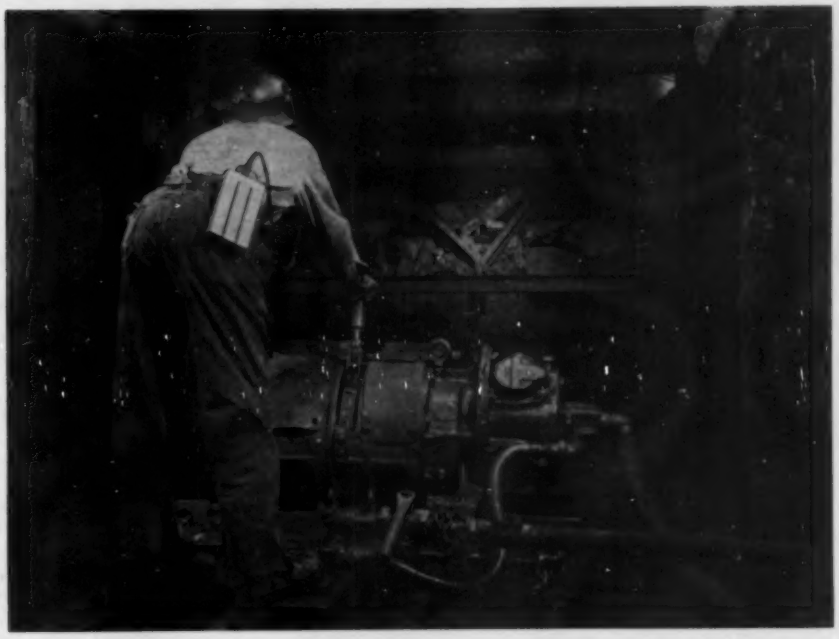
In base metals there were a number of new producers as well as plants that increased capacities of existing facilities. **Rainville Mines** in the Val d'Or district started a copper-gold mine and mill of 300-tpd capacity in April. In February **Chibougamau Explorers** became the third mine to reach production in this area, as the 450-ton copper-gold mill started up. **Lyndhurst Mines** in the Noranda area commenced daily shipments during the summer of 300 tons of copper-sulfur ore for treatment in the **Beattie-Duquesne** mill 20 miles away. Beattie-Duquesne converted its large gold mill to handle copper ore and was bringing its own Hunter mine into production by year-end.

The **Gaspé Copper Mines** large 5700-ton mine, mill, and smelter worked at less than the full rated capacity during the year, owing in part to intermittent power shortage and lack of miners. **Barvue's** 4800-ton zinc-silver open pit mine is being replaced by an underground operation of 3000 to 3500 tons as the economical depth was reached in the pit.

In the Eastern Townships, the old copper workings at **Harvey Hill Mines** near Thetford are being rejuvenated. Underground work and construction of a 600-ton mill was started. **Quebec Copper Corp.**'s increased daily tonnage handled from 800 to 1000. The nickel-copper deposits of **Eastern Metals** were further developed and a 500-ton concentrator started for completion by 1957. **Ascot Metals Corp.**, which introduced Gismo loading and transport to this country, discontinued production because of low grade of ore. **Opemiska Copper**'s recently expanded 800-ton mill at Chibougamau was partly destroyed by fire in October. A loss of four months production time is anticipated, but a new production shaft is being sunk in the meantime.

Other significant developments that will have an impact on future base metal production include the expanded smelter capacity of **Noranda Mines.** This will increase output from 240 to 350 million lb of copper per year within the next year and a half. **Eastern Mining & Smelting Corp.** has started erection of a nickel-copper smelter and refinery at Chicoutimi. There appears little doubt that many new producers will result from the work currently being done through the province. In the Chibougamau camp alone, several sizable projects are in the offing, notably a 7500 to 10,000-ton operation for **Copper Rand Chibougamau.** Others are **Chibougamau Jaculet, Merrill Island, Quebec Chibougamau Goldfields,** and **Bouzan,** to name but a few of the many companies that have sunk shafts and are in the process of proving-up orebodies.

Quebec's struggling gold mining industry again felt the squeeze between the fixed price of gold and rising costs, with the result that operations were discontinued at a number of properties. **Sullivan Consolidated** closed in July rather than try to meet demands for higher wages, but plans were an-



Underground slushing hoist using air-powered winch to scrape broken ore into chutes. Ore is hoisted to surface and transported to Inco's reduction plants.

nounced that the shaft would be deepened and the mine reopened when conditions became more favorable. **Donalda Mines** also suspended milling during the year pending results of an exploration program designed to outline further ore reserves. The **O'Brien** and **Beattie** mines are also understood to have carried out final mine clean-up of remaining ore and are doing exploratory underground work in an effort to outline sufficient ore to warrant production plans.

Molybdenum Corp. of Canada in the **Lacorne** district completed construction in September of a plant for converting their concentrates into molybdic oxide and molybdates, thus eliminating the necessity of having this step performed in the U.S.A. **Preissac Molybdenum Mines** announced the start was made on a 600-ton mine and mill on their property with Molybdenite Corp. to undertake management and operation. Production at **Quebec Lithium,** Canada's first source of this metal, was increased during the first full year of operation as mill capacity was raised to handle 1000 tons of ore from the original 500 tons. Equipment has been obtained to start early recovery of 400 tons of feldspar per day as a byproduct.

New Brunswick

In the **Bathurst-Newcastle** area, **Heath Steele Mines** of **American Metal Co.** is developing as two underground mines and a 1500-ton concentrator is being constructed. Underground mining of lead-zinc-copper ore will feature trackless equipment and diesel truck haulage right to the mill located between the mines. **Brunswick Mining & Smelting** started a large 2000-ft production shaft, and development work was carried out from the original shaft in preparation for mining by sublevel stoping. At the **New Larder U mine** of **Anacon Lead Mines** underground exploration was carried out. **Billiton Co.** commenced shaft sinking on the former Anthonian property after diamond drilling indicated definite ore possibilities. **Sturgeon River Mines** completed shaft sinking and is doing underground work. **Keymet** suspended mining and milling operations in March, having started production from a 250-ton mill in 1954.

Nova Scotia

Efforts were continued during the year by **Mineral Exploration** to outline further tonnages of zinc-lead-silver ores in their large concession on Cape Breton Island. Studies carried out at the Meat Cove property and at Rocky Brook led to formulation of plans to erect a zinc smelter in the province. Surface work was done on the old iron property at Torbrook. **Mindamar Metals,** the sole base metal producer, stopped milling in April.

Plans to start the new Pugwash rock salt mine of **Malagash Salt Co.** were delayed owing to difficulty in sinking through water-bearing formations, although mill construction was well advanced. The company continued to operate the Malagash deposit.

Newfoundland

Newfoundland grew in stature as a major producer of minerals during the past year. **Advocate Mines** uncovered an asbestos deposit at Baie Verte and **New Highridge Mining** made a copper discovery south of Tilt Cove. The **Tilt Cove mine** of **Maritime Mining Corp.** is expected to be in production by May 1957. A 2000-ton mill and two underground mines are being developed. The **Gullbridge mine** of the same company sank a shaft and erected a surface mining plant and announced plans for a 1000-ton mill for completion in 1958. The only producer of zinc-lead-copper in the province, the **Buchans Mining Co.** continued an efficient and highly profitable 1300-tpd operation. Mining is by cut-and-fill stoping using hydraulic filling with sand, and by an underhand square set method of pillar recovery. A large circular 4000-ft shaft was started on a deep extension of the **Rothermere** orebody.

by John McIntosh

Sheep Creek Gold Mines Ltd.,
British Columbia

Western Canada

Total mineral production of Western Canada during 1956 was valued in excess of $650 million. This figure includes metals, nonmetallics, and fuels. Production for 1955 is shown in the accompanying table. In dollar value, in the metals division, zinc was the leader, followed by lead, copper, gold and pitchblende. Among the mining companies, the largest contributor was **Consolidated Mining & Smelting**, followed by **Hudson Bay**.

Saskatchewan

In northern Saskatchewan uranium capacity is being materially increased to meet the requirements of ore discoveries in that district. Here **Lorado** is constructing a 600-ton plant, and **Gunnar** and **Eldorado** are increasing to 1650 and 2000 tons respectively. **Consolidated Nicholson** mine closed.

Anglo-Rouge appears to be the first copper development in the Lac la Rouge area, with prospects of becoming a mine. Ore developed is reported at more than 3 million tons assaying 1.97 pct copper.

Potash Co. of America is sinking a 3000-ft shaft at Patience Lake, where refrigeration of holes surrounding the shaft is necessary to keep the ground firm for drilling.

British Columbia

In British Columbia the emphasis was on copper. In the Highland Valley district, **American Smelting & Refining** is directing exploration of the **Bethlehem Copper Corp.** property. Results indicate a very large tonnage of low grade open pit ore.

Grandby Consolidated, faced with the eventual shutdown of its **Copper Mountain** operation, has what appears to be two potential producers. The **Grandby-Newmont** controlled **Granduc mine** is responding well to the current underground testing program. In addition, Grandby is constructing a 500-ton mill in the old **Phoenix** copper camp.

New copper concentrators, of 1000-tpd capacity, are beyond the drafting board stage for both **Canam Copper**, at Hope, and **Surety Oils & Minerals** at Greenwood.

Bralorne continued to be the premium gold producer in the province, with production in excess of 60,000 fine oz.

Kimberly continued to be the largest producer of lead and zinc, with mining on extraction of pillars as well as from lower levels.

The **Bluebell** and **Reeves McDonald** mines reopened and are now in production. **Bluebell** began recovery of the zinc and lead in tailings from early day operations. Original mine tailings had been disposed by dumping into **Kootenay Lake.**

Canadian Exploration's Emerald mine is well ahead of schedule in delivery of its G. S. A. contract on tungsten concentrates.

Two new iron operations, totaling 6000-tpd capacity, are scheduled for the Canadian Pacific coast. Concentrates are to be shipped to Japan.

Northwest Territories—Yukon

Best known as the northernmost gold mine in North America is the **Grant Yellowknife Gold Mine Ltd.,** which doubled its ore reserves last year to more than 3.5 million tons of 0.78 oz Au. Reports are that the Grant Yellowknife is developing copper reserves to the north. Metal production for the territory should exceed $10 million.

Makeno Mines Ltd. resumed operations during the past summer at a rate of 125 tpd. Heads have been held at 41 oz of silver, 9 pct lead and 11 pct zinc. Exploration is developing ore reserves at 50 pct greater than mill requirements.

Yukon Consolidated Gold Mine produced more than $1 million during its five months operating season, with sufficient ore reserves developed to start operation this May.

Prospecting activity in the Yukon territory was greatly accelerated during 1956.

Manitoba

Hudson Bay and **Sherritt Gordon** were the large producers for 1956. The former has continued exploration at the Osborne Lake property where 500,000 tons of 4 pct copper was developed. **International Nickel** has spent more than $6 million in development at its **Mystery-Moak Lake** nickel properties and expects ultimately to spend $154 million.

Twelve million tons of lithium ore have been developed near **Cat Lake** in southeastern Manitoba. To date more than $1 million has been expended in development of these properties. Near Bernie Lake a three-compartment shaft is under way on **Montgary Exploration's** lithium property—8 million tons of ore averaging 1.85 pct lithium are reported.

Mineral Production, 1955

Product	British Columbia	Alberta	Saskatchewan	Yukon	Northwest Territory
Copper, lb	44,430,000		65,700,000		
Lead, lb	306,718,000			25,761,000	
Zinc, lb	418,330,000		98,650,000	18,780,000	
Gold, oz	256,470		83,800	74,380	318,340
Silver, oz	8,582,000		1,222,500	5,623,000	115,000
Iron ore, tons	698,000				
WO_3, lb	2,254,000				
Pitchblende			11,000,000		12,000,000
Asbestos, tons	16,900				
Coal, tons	1,416,000	4,344,000	2,261,000	8,400	
Gas, mcf		126,750,000	6,038,000		19,000
Crude, bbl		112,200,000	11,487,000		374,000
Total value mineral production	188,053,000	323,741,000	83,770,000	14,406,000	23,454,000

by J. C. Archibald, Jr.

Texas Mine & Smelting Div.,
National Lead Co., Laredo, Texas

Mexico

The big news in mining in Mexico is an increasing interest in nonmetallics. Barite and fluorspar have been very active. Mexico has potentially a large market for feldspar, but feldspar is still being imported from the U. S., although domestic producers have increased production. Quartz is being supplied almost entirely from domestic sources.

Revisions in the mining law, particularly with the permission given for increased depreciation and amortization rates, have been very attractive to many of the mining companies. These new provisions specify that the cost of equipment and development work and the cost of the property itself can be written off for the estimated life of the deposit, or of the lease should the lease be the governing factor.

A large new strike of mercury has been reported at **Huahuastla,** Gro. A new mill was completed, and has reportedly been placed in operation at **Huitzuco,** Gro. Because of the guaranteed price, mercury mining continued on an even keel during the year.

The manganese picture has not yet changed in spite of the great increase in price paid domestic producers—who are now receiving Indian prices. The increase in prices should bring increased production during the next year.

The major base metal mines have continued at practically the same level as in recent years. One new mill in the Chalchihuites area has gone into operation, and another reportedly is ready for operation in the same area. Mexico is still exporting some copper, but the consumption in Mexico has increased tremendously owing to its use by the relatively new fabricating industry. That industry is taking all the production from the major producer, and it is estimated that by 1962 Mexico will need to import copper for her domestic needs. Heavy industry in Mexico, in general, is increasing, and a similar situation could exist with regard to lead-zinc not too many years hence.

Titanium is no longer in the forefront of the news, but it is understood that at the rutile strike in Pluma Hidalgo, Oax., development work has continued. Mexico possesses large reserves of ilmenite, and there is a great potential for titanium dioxide consumption.

Most of the sulfur companies working on the Isthmus are now in production. The Mexican Government has not agreed to increase the acreage available for prospecting, and unless the acreage is increased the life of the ventures is definitely limited.

Increased activity with regard to iron ore was noted with the announcement of a new deposit near Diudad Camargo, Chih. There is also activity in the state of Jalisco at Pihuama, and in the state of Oaxaca.

Caterpillar D6 tractor with 6A dozer carves out a road to expedite sulfur production in southern Mexico.

by G. A. Gustafson

Alaska

During the past year prospecting and exploration has intensified. Several large companies are entering the scene as well as local participants, a result of the increase in population in the past ten years.

Admiralty Alaska Gold Mining Co. is exploring a nickel-copper lode at Funter Bay. Two tunnels are being driven at 1425 and 1700 elevations to intersect the orebody.

Kennecott is exploring on a full-time basis the once rich Chitina copper area, site of the fabulous Kennecott mine, with hopes of relocating a new copper formation.

The **Kuskokwim River Quicksilver mine** located near Sleitmute is producing about 400 flashes per month. Difficulty is experienced in retorting due to the stibnite present in the cinnabar.

Commercial uranium is being developed by **Climar Uranium** on the Prince of Wales Island off Ketchikan. This is the original Ross-Adams discovery. Nearby **Union Carbide Nuclear** is negotiating for the claim of I & L uranium.

The vast iron deposits of southeast Alaska have received new life following successful negotiations with the Japanese steel makers to accept 3 pct titanium in the iron ore.

by K. A. Lehner
Joy Mfg. Co., Salt Lake City

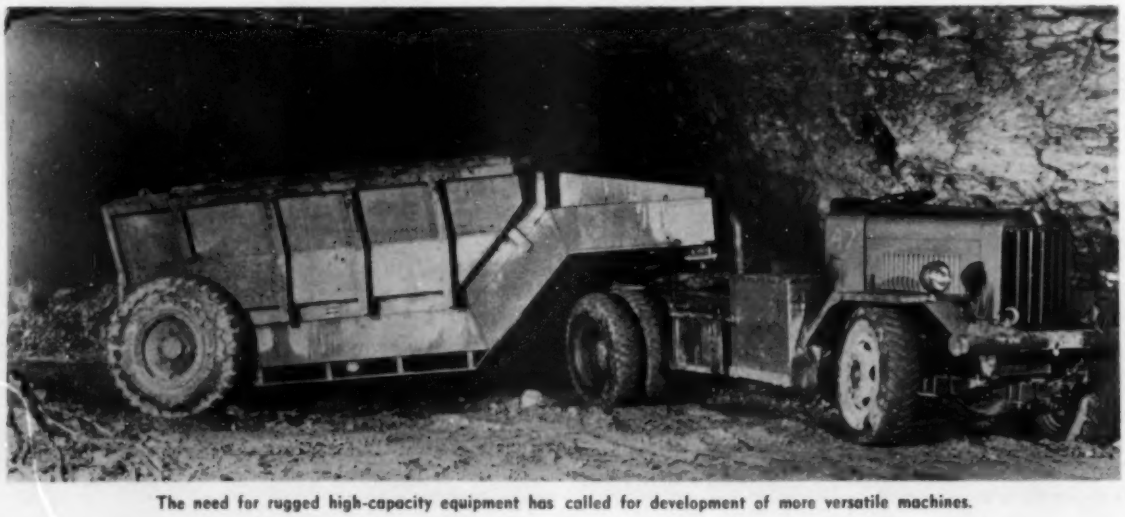
Underground Equipment

The year 1956 has been marked by the generous development of new ideas and new tools to help underground operators improve working conditions, step up production rates, and set new marks for efficiency in different and varied phases of their operations. Underground exploration, drilling methods, drilling bits, drills, slusher control equipment, loading machines, and high speed propelled rotary drills have made their impressions.

Smaller, heavy duty, skid-mounted, underground core drill rigs equipped with hydraulic-type swivel heads are available. They can have separate air motor driven hydraulic systems or built-in hydraulic systems to provide controlled and variable feed pressures, to be used with all standard sizes of core drill tools. In general, improved core recovery has resulted from the use of hydraulic-type feeds. Increased daily penetration has resulted, greater hole depths have been drilled, and a reduction in overall drilling cost has been attained.

Canada reports introduction and acceptance of a more effective development in hard rock mining. The enlarged holes in the burn or shatter cut drill pattern improve breaking and reduce the actual number and size of holes to be drilled. Widespread use of air feed leg drills has posed a problem of drilling the large diameter holes, which are left unloaded and to which other holes break. Air leg drills usually drill holes of 1⅜-in. to 1⅝-in. diam. Penetration rates when drilling 2¼-in. or 2½-in. holes are very slow. Introduction of the *Dimitrieff reamer bit* has offered an immediate solution. The air leg operator proceeds in the regular manner to drill a pattern of 1½-in. holes. The Dimitrieff bit is used to drill the 2½-in. Burn holes by enlarging the 1½-in. holes, which were to be left unloaded. The Dimitrieff bit has the same straight circular taper locking arrangement as the bit, copperhead taper type, in widespread use. This eliminates the need for extra or special steel. A pilot nut device holds the drill steel centered in the drillhole being enlarged, while the reamer bit directly behind enlarges the annular area to produce the enlarged hole. Results reported are reduced drilling time, better breakage, and consistently deeper rounds in hard ground.

The Cryderman mucking machine has made its appearance for incline shaft mucking. The first machine has been put into actual production work. At this writing no definite results are obtainable, but it is expected that some improvement will result in this difficult mining problem. This machine consists of a 20-ft cage built in two 10-ft long sections for ease of installation and handling underground. A telescopic-type boom with a 14-ft side swing in any direction and with extendable feature 15 ft capable of retracting and revolving allows for great flexibility in performing the many maneuvers needed to dig, handle, and load in a small incline shaft. Operation is manual, providing controlled compressed air to either end of seven air cylinders. Two control levers by proper manipulation actuate the extending of boom section, swinging the clamshell into place, and providing the force needed to load and close the clam, retract, place it in unloading position over skip or bucket on either side of machine, and to unload it for further digging. The clam can handle general size muck, oversize boulders that have to be handled separately, or wet or dry material. It requires about 500 cu ft of 90 lb of air per min for good operation. Certainly more will be heard from this machine in the future, as many operators are very interested in this problem.



The need for rugged high-capacity equipment has called for development of more versatile machines.

Two jumbo drill machines with jibs. Crawler-mounted equipment is coming into its own in underground operations.

Introduction of the Joy Microdyne, wet, inertial-type dust collector designed to collect particles of gas and air streams offers a possible solution to many severe dust problems. This machine, made in many sizes and capacities (4000 cfm to 48,000 cfm) is so constructed that it can be mounted directly in pipe or duct lines. Space requirements are practically nil because the unit can become a part of the duct system. The unit can be used very effectively to clean the dust-laden air streams near car loading or unloading points, crushers, shaft stations, block caves, or other points where dust count in the air streams must be held to safe limits. Water is required for wetting dust particles. Quantities under normal 60-lb pressure are stated to be 1 gpm for a 2500-cfm unit, 4.8 gpm for a 12,000-cfm unit, 19.2 gpm for 48,000-cfm units. The machine separates the dust and water in the form of slurry at the bottom, which is the drain section. This slurry can be saved and pumped or go to waste. Efficiencies are very high, the manufacturer stating that 100 pct collection of 5-μ size particles by count, or 83 pct of 3-μ size by count can be taken from most air streams. Certainly this unit has much to enhance a bright future, as it fits a spot both underground and on surface where the need is great. The size characteristics, the ease of installation, maintenance, cleaning, and control mark it for underground service.

Crawler-mounted underground equipment has come to the fore more than ever during this year. The need for rugged high capacity machinery has called for the development and introduction of more and varied machines. Primary in this field has been the introduction of heavy duty, medium-sized loading machines on air-powered or electric-powered crawler-type mounting. Such a unit has been announced during 1956 as the Eimco Model 630 Series and fills that gap where a unit capable of handling and loading hard abrasive rock has been needed. Conversion to other types of machine is possible. It can be made into a standard tractor for pulling, into a bulldozer for pushing, fork lift truck, back hoe trencher, timber setter, and drill mounting. The coming years will see widespread adoption.

The advent of roof bolting has created a serious problem and has also created an answer. Wet-type roof bolting with water for drilling creates a problem in many places where water is scarce or not desired. A new bolthole vacuum cleaner catches dust at the hole collar generated by percussion or rotary drilling. The unit consists of a positive displacement vacuum pump attached by flexible hose to two filter barrels containing filter elements. Positive vacuum is created by use of a special spring-type jack, which seats the special head against the roof or back. The drill bit and steel drill through this head. Rock chips and dust are sucked through the head and attaching hose to filters. The manufacturer states that drilling can be successfully accomplished at a distance of 200 ft from pump and filters. The same company has also introduced a unit known as the MSA Drill Dust Bucket for use primarily with auger steel. The Dust Bucket is approved by the U. S. Bureau of Mines. It requires no power and is held in place by a hanger assembly with a rubber seal against the work surface. The auger steel works through it and dust or particles resulting from drilling fall into the bucket. At completion of each hole, the unit is emptied. It is most successful for roof bolting.

Many operators have learned from actual experience that the proper use of remote control of two-drum and three-drum slushers does offer a means of increasing manhour output as measured in tons of material moved. This system of control makes it possible for the slusher operator to stand at a point where he can actually control the scraper loading operation and thus be sure that a full scraper is brought in on each trip. More slusher hoists with remote control—air hoists, air electric, or all electric—will be used as the knowledge of increased production becomes more general.

by J. C. O'Donnell
Shaft & Development Co., Salt Lake City, Utah

The Problem of Shaft Sinking

Shaft sinking has always been considered the toughest assignment of the entire mining operation. Few men have found the work attractive, as shaft workers have endured poor ventilation, an abundance of drainage water—sometimes acid—and many delays caused by the mining operation above, and in addition, the job of hand mucking.

As an inducement for the job, shaft men were always paid a higher rate than the prevailing miner's scale, yet even with this incentive only the more rugged followed shaft work. Outstanding among these early day men were the Finns, who by their prowess proved equal to the severe task. As immigrants they learned their mining in the iron and copper regions of Michigan, only to move west as the new fields opened.

A cylinder within the telescopic boom of this Cryderman shaft mucker permits it to extend 14 ft 8 in. to a total length of 31 ft 8 in. from the gimbal.

It was common practice for mines, after setting up the shaft job, to hire one leader or pusher who supplied the three shift crews and supervised the job. Management's task was to furnish tools and supplies and check the shaft lines—the Finns supplied the rest.

Because the operation moved along satisfactorily, little thought was given to any improved sinking methods. With such an ample market of good tough shaft miners, no mechanization was forthcoming, and yet it is interesting to note that for 50 years clamshells, power shovels, and traveling cranes had been known to the industry. Probably one reason for the lack of change in methods was the fact that these early day shaft men were trained specialists who made satisfactory footage by hand mucking.

Always eager to cut costs, the mining industry introduced newer methods and better equipment into the mines. Slusher hoists and scrapers eliminated hand mucking in stopes. Overshot loaders in level development with larger cars and locomotives replaced the car man and hand mucker. Self-rotating stopers replaced the old wiggle-tails and power-feed drills, and detachable bits and improved drill steel also found their way into the picture. But shaft sinking adhered to the antique method of hand mucking.

To minimize mucking in larger shafts one method used was to sink only two compartments, then stope the remainder of the shaft. In this manner the bulk of the broken rock was handled by gravity. Where the sinking site could be reached from different access levels, another practice has been to raise the shaft either in part or full section. This method was effective, especially where coarse muck made the sinking operation a slow, costly job.

Probably the first improvement in handling broken rock was the use of the mucking pan. The improvement was that instead of the back-breaking job of lifting rock into the sinking bucket much of the muck could be scraped into the pan. With the use of a single drum hoist mounted in the timber the pan was raised alongside the *long tom* sinking cage. Chains from the cage were attached to the lip of the pan to control the discharge of muck into the mine car on the sinking cage. Later the use of sinking skips replaced the cage and car.

From the iron country came the first use of the double drum slusher in handling shaft rock. When the round was fired the bulk of the muck was thrown against one wall. Then with a minimum of hand mucking the small slusher ramp was installed, being supported by a long bar set against the shaft walls. A sheave block was anchored to each end of the shaft wall, and with the slusher set above in the timber, the scraper moved longitudinally in the shaft, pulling the rock up the ramp into the sinking bucket.

Newer ideas and improvements gradually came into shaft sinking in the way of experimental rounds in both full bottom and bench type; better ventilation; air and water manifolds; and blasting mats and

bulkheads. A safety feature was the replacement of fuse blasting with electric detonation. It was always a problem to keep the cap and fuse water repellent, plus the chance of misfires and the danger of a hoist failure after *spitting* the round. Electric caps eliminated many of these former hazards.

Standard equipment from early days, hand held rock drills are still used in shaft sinking, with greatly improved drills, steel, and carbide bits.

An innovation in shaft drilling was the use of air bars and drifter drills. The advantage of these machines was that deeper and better patterned rounds were drilled with less fatigue to the miner, as the drills were moved transversely along the bars in the shaft. This was a move in the direction of the jumbo, whose acceptance in shafts was slower because of the small compartment sections. Ease of handling in the open elliptical and circular shafts today finds a greater use of the drill carriage, which has made the miner's job much easier, especially in pulling long rods from the hole.

The war years saw the passing of the old time shaft miner. It was a problem to replace him. This, with the ever increasing cost of labor and supplies, gave rise to the thought of changing the arduous job of shaft mucking.

Among the first of the improved methods was E. J. Longyear's introduction of the Riddell mucker in a shaft at Barberton, Ohio, in 1943. With two 90-lb rails mounted on *I* beams and supported on the end plates of the shaft, the carriage moved lengthwise of the shaft. There were two operators in the carriage, one on the traction motor and the other controlling the raising and lowering of the clam. Tag-line men in the shaft bottom swung the clam into position before the operator dropped it into the muck pile. This machine was the first to eliminate hand mucking in vertical shafts. There have been modifications of the Riddell since its inception, and it is widely used in shaft sinking today.

With adoption of the Riddell there appeared many variations of clamshell mucking. One practice is to place the operating motors at some distance above the muck pile in order to make easier swinging of the clam for the tag-line men in the bottom. A greater open area of shaft is required for this operation.

Another version is to place a single drum tugger within the clam, and from two ropes on the tugger a shaft man actuates the opening and closing of the clamshell. Raising and lowering of the clam is done by the main hoist.

Still another practice is the use of a panel board in the shaft bottom whereby one man controls the raising and lowering of the clam and the action of the jaws, with tag-line men swinging the clam into position in the shaft bottom. Two solenoid, air-operated hoists at the shaft collar supply the power for this unit.

Many other variations of clam shell mucking are used, such as the hydraulically controlled clam and the clam that is operated by being attached to the bottom of each cage of a double drum hoisting set-up. Here an operator in each cage controls the action of the clam below as it is hoisted and dumped in a pocket above.

In addition to the Priestman and air-powered grabs, the *orange-peel* or pneumatic grapple with its six tines has had use in shaft sinking. Much like the clam, it has had a varied application, being controlled from a panel board in the bottom, from a cable way, or used as a straight grapple. Users of the orange-peel type of loading claim its big advantage is that in loading varied size rock two tines will grip a large boulder while the remaining tines close into position holding fine muck within the grapple.

As much consideration was given vertical shaft mucking, mechanization appeared in some types of inclines also. The first such mechanization was the slusher, originally with the single, then with tandem scrapers. Many variations of slusher mucking have been used in incline mucking.

The overshot or rocker-type shovel that became standard equipment in level mucking was converted for use in incline shafts. Conversion of the standard loader to an incline machine was accomplished by attaching snubber reels to the rear wheels of the loader. Over these reels a holding cable was reeled. Traction operation was a combination of torque on the wheels and retraction of the snubber cable. On inclines from the near horizontal to 30°, this machine has been effective.

S. W. McDougall, manager of **Bunker Hill mine,** designed a self-loading skip with a 20-cu ft bucket. This unit was lowered to the face of the incline where the 20-cu ft bucket was loaded by a cable operation. The loader was hoisted and dumped into a pocket.

One of the most recent developments applicable to both incline and vertical shaft sinking is the Canadian Cryderman mucker, whose action is controlled by seven air cylinders. From his cage compartment one man operates two levers that control the movement of the telescopic boom and the position of the clam bucket in the shaft bottom. Unlike a gravity force, the desired pressure for crowding the clam bucket into the muck pile is a positive controlled action, while the telescopic boom resembles the reaching action of a human arm. This machine is unique because of its successful use in both vertical and incline shafts today. It is reported that 41,000 ft of Canadian shafts have been sunk with this machine to date.

As these improvements continued, framed timber —always a popular means of shaft support—was being replaced in part by the use of concrete in square and rectangular shafts. In the Southwest several circular shafts were sunk. Advocates claim greater compression and better ventilation in the circular type. Recently the overshot mucker has been used in this type of shaft, replacing the clamshell for loading broken rock. Following the perimeter of the shaft, the tractor-mounted loader mucks around the shaft bottom, always keeping the broken muck pile in the shape of a saucer. The loader is hoisted to surface in the open shaft prior to blasting.

Shaft sinking at the individual property has been an intermittent operation, and, generally, deepening was carried on only when one or two levels were needed for mining. There arose the problem of holding good shaft crews during the interim, and the shaft contractor with his trained crews was brought into the picture. Along with this has been added competitive bidding by contractors for shaft jobs.

All these conditions have led to faster and more efficient methods of sinking which today are a far cry from the old hand mucking days. Yet the industry can look forward to even more developments and refinements in the job of shaft sinking ahead.

Annual Review

Mining Geology

by P. W. Guild

DURING 1956 the application of geology and related scientific disciplines to the search for new mineral deposits went forward on an ever widening front. Spurred on by record-breaking consumption of many of the established commodities and new uses for minerals and metals that were hardly known a few years ago, the profession is figuratively leaving no stone unturned in the effort to insure that adequate raw material supplies will be available for the future. More money was spent and more people were engaged along more lines of research than ever before. A huge project to map much of the Canadian Shield area by photogeologic methods stands at one extreme; application of isotope ratios to ore finding stands at the other; between them the more traditional techniques are being increasingly refined.

In the Fiftieth Anniversary volume of *Economic Geology*, published late in 1955, Alan Bateman sketches the development of fundamental concepts as recorded in the pages of the journal over the first five decades. An additional 24 review articles cover individual aspects of the field and constitute a base for further advances.

The XXth International Geological Congress at Mexico City in September brought together several thousand geologists from all parts of the world. In general, no novel concepts were presented in the section devoted to modern ideas on the origin of mineral deposits, but numerous contributions from Russian geologists were of interest if only because their work is not generally known in this country. It is evident that they are working along the same lines and are essentially in agreement with geologists in the West. Their papers bore down heavily on regional metallogenic provinces, the relationship of ore to major structural features, and the application of geology to prospecting, suggesting that the Russians are searching for new ore as actively as we are.

In the rapidly expanding area of fissionable materials, USGS Professional Paper 300 presents the first comprehensive description of the geology of uranium and thorium deposits in the U.S. Eighty-nine articles by geologists of the USGS and the AEC give an impressive account of what these two agencies have been doing for the past decade when the effort expended on uranium "greatly exceeded that given to the search for any other mineral commodity during any similar period of history." The success attained to date in ore discoveries has been primarily due to the radiation-detection equipment available to prospectors, but as in other metals, a more analytical method will be required as all the near-surface deposits are found. Knowledge of the geology of uranium and thorium already equals or exceeds that of any other metal, so that techniques developed in this work will undoubtedly be turned to the search for the more traditional mineral commodities.

According to E. L. Clark of Four Corners Uranium Co., geologic guidance is already being put to practical use by the uranium industry. Recognition of the control exerted by structural features on the occurrence and distribution of ore has proved invaluable in tracing extension of known deposits and finding new ones. Some companies are exploring favorable structures where suitable host rocks are present but not known to be mineralized.

Attack on Regional Problems: It has long been recognized that district studies may lead to the discovery of new deposits at favorable structural or stratigraphic locations, and indeed this type of endeavor has been a major contribution of government organizations. Regional studies are the logical next step, but they have rarely been undertaken or carried to completion because of the limitations of money, men, and time. The outstanding exception is, of course, the Colorado Plateau.

However, just as the swift advance in photogrammetry has revolutionized the preparation of base maps, new photogeologic techniques reduce appreciably the cost and effort of geologic mapping in some types of terrain. An undisclosed group of mining companies has contracted with the Photographic Survey Corp. of Toronto to map some 357,000 square miles of the Canadian Shield on mile-to-the inch mosaics. This project, known as *Operation Overthrust*, will cost about $2 million and will be completed in two and a half years. All available geologic information will be compiled on the area, which extends from Manitoba to Labrador and includes parts of Minnesota, Michigan, and Wisconsin. Gaps will be filled in by photogeologic techniques, supplemented later by field work. Aerial color photographs will be made of the Blind River, Sudbury, and Bancroft districts to determine whether clues to mineralized areas can be picked up that may guide in the search for new districts.

Operation Overthrust is the most ambitious application of photography to regional mapping, but by no means the first. It is the outgrowth of more

modest studies of New Brunswick, Alberta, Ceylon, and Pakistan made by the same company. These studies in turn grew out of methods long used in the search for petroleum. The spectacular finds of the last few years in the Bathurst area have spurred a search for possible continuations into northeastern Maine, where at least half a dozen companies are active. To date there have been no announcements of discoveries.

To provide a sound geologic basis for detailed exploration under the new President's Mineral Policy program the USGS is stepping up its mapping of potentially favorable areas. The first stage of this program was to expand geologic mapping in selected areas in Maine, the Southeast, and the Pacific Northwest.

New Discoveries: Although major finds are being made abroad with increasing frequency, U.S. mining developments are depending more on profitable exploitation of lower grade materials by improved technology. The outstanding development along these lines was undoubtedly the large-scale, commercially successful beneficiation of the Lake Superior taconites and jaspilites at the E. W. Davis plant in Minnesota and the Republic mill on the Marquette Range (MINING ENGINEERING, November 1956). The enthusiastic reception accorded the product apparently will revolutionize the iron ore industry; even some shipping-grade ores may be upgraded to match the superior 63 to 65 pct Fe pellets and nodules. Advantages of the latter are economies in transport per unit of iron, better and more uniform structure, and greater metal output per blast furnace at lower consumption of coke and fluxes. The probable effect on mining geology will be twofold: a decreased emphasis on exploration for and delineation of higher grade ores beneficiated by natural processes, and increased interest in favorably situated large reserves of lower grade material amenable to concentration.

Already new developments are being announced almost monthly, particularly in Canada. Some of these occurrences have been known in a general way for years; the tipoff for others has usually been from magnetic anomalies. There is also active interest in iron formation areas from North Africa to the Union of South Africa, Australia, India, and South America.

Geologists now generally consider that these extensive deposits are chemical precipitates, but from this point on there is little agreement, especially on the source of the materials and the role of the volcanic phenomena usually accompanying deposition. A. M. Goodwin advocates, in *Economic Geology*, a volcanic source for the iron and silica of the Gunflint iron formation, suggesting that submarine springs may have contributed the major part of the constituents. Each carefully documented description is a welcome addition to the literature on this subject. The definitive work is still to be written, however, if indeed it ever is.

An unexpected bonus from the drilling campaign conducted in the Belcher Islands in Hudson Bay, which has already proved up an immense reserve of magnetic iron formation grading about 30 pct Fe, has been the discovery, reported by the *Northern Miner*, of copper ores said to run from 6 to 9 pct Cu. Base and precious metal deposits more or less closely associated with iron formation are of fairly frequent occurrence in several areas of the world. The explanation probably lies principally in the susceptibility of the chemical precipitates, both carbonate and chert, to replacement. The relative ease of detection of iron formation by airborne magnetometer may lead to other nonferrous discoveries elsewhere.

The contrast between U. S. and foreign developments is well illustrated by the aluminum industry. At home, Anaconda Co. has turned to the use of high-alumina clays in the Pacific Northwest for production of alumina, while preliminary reports indicate that a very large new bauxite district has been discovered in the Cape York area of northern Queensland, Australia.

The Strat-Mat electric furnace method of producing ferromanganese directly from low grade manganiferous material, developed by Marvin J. Udy, was successfully demonstrated and should be in commercial operation by the end of the year. Large reserves of lean iron formation grading approximately 10 pct Mn are available in New Brunswick, and similar ore in Aroostook County, Maine, should also be amenable to the process. In the eastern hemisphere very large deposits of high-grade manganese have been found in French Equatorial Africa and the Union of South Africa, each apparently in a sedimentary iron formation environment, and the deposits of India have been shown by J. A. Straczek and the Indian Geological Survey to be larger and more continuous than had previously been supposed.

An important new source of high grade manganese ore has been opened up in Brazil. Donald M. Fraser writes that shipments began in late 1956 from deposits in the Territory of Amapa that were developed by ICOMI, a Brazilian mining firm in which Bethlehem Steel Co. has a part interest. The deposits discovered about 15 years ago are situated in a dense tropical rain forest along a zone five miles long that straddles the Amapari River 100 miles northwest of Macapa, territorial capital on the north bank of the Amazon River. Some two dozen deposits of manganese oxides, chiefly cryptomelane, were formed by deep tropical weathering of metamorphosed manganiferous sediments. After reserves in excess of 10 million tons were proved by 33,000 ft of diamond drilling, the decision was made to go ahead with development.

Sulfide Research: The Geophysical Laboratory of the Carnegie Institution of Washington has renewed its equilibrium studies of the sulfides and related selenides and tellurides which had been interrupted during the war. Measurements on numerous experimental preparations made by Einar Jensen have been completed, and a paper by J. W. Greig describing the system Cu-Fe-S will appear next year. Kullerud and others at the Laboratory are working on several systems of great importance to economic geologists, among them the Fe-Ni-S, Cu_2S-CuS, CuS-CuSe, and Ag-Te systems. An immense amount of work remains before all aspects of the complicated field of sulfide equilibria are known, but a firm understanding of the simpler systems is being established on which to base further work. Practical results of benefit to the mining geologist may seem remote at present, but this research will undoubtedly lead to a better understanding of the ore-forming processes.

Kullerud reports that the FeS-ZnS geological thermometer has been put to work in Norway, where higher-temperature (more iron-rich) sphalerite marked the channelways of fluids in several moderately dipping ore shoots. Drilling at the inter-

Site of important new source of high grade manganese ore. Crushing plant, belt conveyors, and loading bins at Amapa, Brazil.

section of the projections of these converging channelways found a large deposit.

Fryklund and Fletcher applied the ZnS-FeS thermometer to the Star mine, Coeur d'Alene district, and conclude, in *Economic Geology*, that sphalerite in the upper part of the deposit formed at a higher temperature than that from some 5000 ft deeper. Detailed studies of many deposits will no doubt be made, and answers can be expected to questions such as that raised by the authors: "Do ore shoots first form at the bottom and build upward, or vice-versa?"

That sphalerite is not the only sulfide capable of serving for geologic thermometry is demonstrated by R. G. Arnold, of Princeton University and the Geophysical Laboratory, who has investigated solid state reactions between pyrrhotite and pyrite and found that the composition of the former, when grown in equilibrium with pyrite, varies sufficiently with temperature to provide a sensitive scale suitable for application to natural assemblages.

Because pressure at the time of mineral formation, ordinarily an unknown factor in ore deposit studies, affects the composition of the various mix-crystals, absolute temperatures can usually not be assigned, but the discovery by H. P. Eugster, also of the Geophysical Laboratory, that the muscovite-paragonite (sodium mica) join is temperature-sensitive may eliminate this problem in ores where sulfide and mica assemblages occur together. By measuring the apparent temperatures of formation of both the sulfides and micas and applying the corrections necessary to resolve the discrepancy, it is possible to determine both absolute temperature and pressure. Obviously the successful application of this method to representative deposits could greatly assist in resolving some of the problems in classifying epigenetic orebodies.

Isidore Adler and J. M. Axelrod *(American Mineralogist)* describe the application of the recently developed curved-crystal, reflection-type, focusing X-ray spectrometer to mineralogical studies. Grains as small as 0.5 mm diam have been analyzed successfully without removing them from the polished section or in any way damaging them. The usefulness of this new technique will be obvious to any geologist who has tried to identify the minerals in a fine grained complex ore.

Ore Genesis: The old argument between *magmatacists* and *lateral secretionists*, dormant for many years, is being resumed. Although the latter now call on more elaborate processes to explain how the metal content of sediments can be concentrated into workable deposits, by the same token they are expanding into the higher temperature assemblages and no longer restrict the theory to low temperature ores in areas where no intrusive rocks occur. Thus R. W. Boyle ascribes the formation of the Yellowknife gold deposits to mobilization and redeposition of elements present in amphibolite and metasedimentary rocks under the influence of a strong thermal gradient promoted by intrusion of nearby granite masses. Sven Gavelin presents evidence, in *Economic Geology*, that the metals in the sulfide deposits of northern Sweden were derived from the sediments during granitization and gneissification of the terrain, in which, he points out, there had already been some concentration by sedimentary processes.

Extensive studies of Steamboat Springs, Nev., and other thermal spring systems have led D. E. White to conclude that the proportions of water of meteoric, connate, and juvenile origin vary considerably from place to place. Most hot springs appear to consist dominantly of heated meteoric water. Some of the metal content of the waters was contributed from magmatic sources, but some also probably resulted from the leaching of underlying volcanic and sedimentary rocks. He write in the Anniversary Volume of *Economic Geology*: "In general, geologists have probably had an oversimplified picture of the origin and nature of ore-bearing solutions and many have favored the derivation of most hydrothermal ore deposits from a single type of ore solution." White's review of hot springs and related ore deposits indicates that although some deposits were formed by solutions closely related to volcanism, many others probably were formed by circulating meteoric and connate waters. It seems that the common use of the term *hydrothermal* to denote magmatic or juvenile water should be abandoned in favor of the literal meaning.

Geologic age determination continues to occupy a number of workers and provoke much discussion, particularly on the discrepancies in results obtained by the different methods. On the basis of acid washing experiments with sphene, zircon, biotite xenotime, monazite, etc., George Tilton shows (*Transactions*, American Geophysical Union) that redistribution of both parent and daughter elements can give erroneous answers. Eckelmann and Kulp (*Bulletin*, Geological Society of America) apply several

Loading manganese ore, Amapa, Brazil. Dense jungle growth and deep weathering of country rock slowed the progress of geologic mapping.

U-Pb and Pb-Pb ratios to a suite of samples from Lake Athabasca and conclude that there have been at least two periods of lead exsolution, probably due to mild regional metamorphism, since the initial deposition of the ores. They state: "Agreement among the isotopic ages from a given locality is excellent evidence that the true absolute age is known. Further, it is proof that the area has not been subjected to appreciable thermal rise since the time of formation of the mineral."

Reconciliation of apparent age discrepancies will eventually lead to a better understanding of the history of an area through the reexamination of all the evidence, even though they may seem at first to upset a lot of geologic applecarts. A good current example is the recent dating of the lead in the Coeur d'Alene district as probably Pre-Cambrian although the deposits have generally been considered on structural and intrusive evidence as Cretaceous.

Although it is just in its infancy, perhaps the most promising of all the new techniques in use today is the *stable isotope* research, now being actively pursued at several institutions. Relatively few papers have appeared to date, but it is safe to predict that the number will increase rapidly in the near future.

Sulfur isotopes may provide valuable clues to the source of the sulfur in ore minerals. J. L. Kulp and his associates at the Lamont Geological Laboratory report that although the S^{32}/S^{34} ratio is ordinarily constant for the various sulfides of a given deposit, the ratios diverge widely in ores from different areas. As fractionation of the isotopes occurs in a near-surface sedimentary environment, ratios which differ greatly from that for sulfur in meteorites, taken as the average, are believed to indicate derivation from the crust. Conversely, sulfides from deep-seated mafic rocks have the meteorite ratio. The wide variation is interpreted as indicating that most hydrothermal solutions originate in the crust, although not necessarily without remelting and formation of magma.

Tuzo Wilson and his coworkers at Toronto, on the other hand, cite the regularity with which the ratios of radiogenic lead isotopes relative to lead 204 vary in the shield areas as evidence that lead ores have risen from a uniform source, presumably in the mantle. They point out, in the *Transactions* of the Canadian Mining and Metallurgical Institute, that many of the important mining districts of Canada lie at or near the boundaries between the subdivisions of the shield, and they infer that great faults served as channelways for the ascent of juvenile ore solutions.

Alan Bateman and M. L. Jensen attempted to apply sulfur isotope ratios to the problem of origin of the Rhodesian Copper Belt ores, but found that they lay in a zone of overlap and could be explained either as syngenetic from biogenic H_2S or as hydrothermal. They announce *(Economic Geology)* that further work on this and allied problems has been initiated at Yale.

Variations in hydrogen-deuterium and O^{16}/O^{18} ratios should provide clues to the nature of the waters in thermal springs and hence to the ultimate

source of the metals in ore deposits. The O^{18}/O^{16} ratios are extremely temperature-sensitive in the lower ranges and may be of great value in indicating zones of hydrothermal activity. A. E. J. Engel, R. N. Clayton, and S. Epstein have found in the Leadville district that oxygen isotope ratios in the dolomite halos developed in the limestone vary systematically with respect to ore and obvious conduits, and the effects of the hydrothermal activity can be detected at distances of miles from ore. Limestone, dolomite, and chert beds unaffected by hydrothermal solutions contain oxygen approximating that in other unaltered sediments, but the O^{18} content decreases toward ore and feeders, so that lines of equal O^{18} content tend crudely to encircle ore. The method may have widespread application in exploration for buried deposits.

A program of research into the environment of ore deposition has been started by the USGS. Pressure, temperature, and chemical composition of the ore-forming fluids will be investigated. Edwin Roedder and Lloyd Ames, Jr. have succeeded in isolating and analyzing the fluid trapped in inclusions that may represent the solutions from which ore minerals were deposited. Chlorides and carbonates of potassium and sodium are the most abundant constituents. Variations in composition sometimes permit identification of individual veins and should assist in structural interpretation of complexly faulted areas.

New Interest in Rare Commodities: Demand for the less common elements continued to grow, and with it the search for deposits that formerly were hardly considered worth looking for. A lithium boom caused widespread staking in northern Manitoba. Unprecedented demand more than doubled selenium prices and set off a search for new sources; however, increased recovery from the copper refineries and the development of substitutes for some uses caused a slackening of interest by year end. During 1956 the AEC contracted for the production of sizable amounts of beryllium, zirconium, and hafnium metal for use in the expanding reactor program. E. W. Heinrich at the University of Michigan draws attention to the new interest in the yttrium group of rare earths, certain of which have considerable potential value in the atomic energy program.

Although the prices of columbite and tantalite dropped sharply after termination of the foreign stockpile purchases by the Government, exploration of the pyrochlore deposits of Canada, Africa, and Brazil continued and a number of papers describing the geologic occurrence of these unusual mineral assemblages appeared. Toward the end of the year the Geological Society of America published a review article by W. T. Pecora summarizing present knowledge of the carbonatites, which with the related alkalic rocks contain an impressive reserve of such rare commodities as columbium, titanium, zirconium, and rare earths. The author concludes that the carbonatites are of intrusive origin, formed by precipitation from extreme differentiates in which magmatic CO_2 of unknown source was progressively concentrated during crystallization of the silicates. Intensive search for additional mineral deposits is warranted in all alkalic petrographic provinces.

An entirely new port has been constructed on the Amazon near Macapa and a 150-mile railroad built to the mine area.

Konrad Krauskopf writes, in the Anniversary Volume of *Economic Geology*: "Widespread enrichment of rare metals takes place in four kinds of sedimentary environment: 1) coal swamps; 2) shallow marine sediments where petroleum accumulates; 3) stagnant bottoms and open shelves in areas of upwelling water; 4) semi-arid slopes and basins where red sandstones and conglomerates are deposited." His suggestions for prospecting should be of value as the search for new reserves of these metals intensifies.

H. E. Hawkes and Harold Bloom describe, in the November issue of MINING ENGINEERING, a method of geochemical prospecting based on rapid and simple field tests for heavy metal content of stream sediments that has been extensively used in reconnaissance of New Brunswick and the Gaspé Peninsula. In three field seasons 43 strongly anomalous areas were found, of which nine have been selected for physical exploration. "To date, four of these nine have been explored by diamond drilling, and in every case have been found to be associated with significant base-metal mineralization."

In the December issue of MINING ENGINEERING the application of geology to the day to day problems of mining is admirably described by F. G. Snyder and J. A. Emery, who show how attention to minute detail pays off in the southeast Missouri Lead Belt. Relation of ore intersections in drill core to lithology and sedimentary structural features permits evaluation and classification of the deposits in advance of development. Classification by mining habit, meaning here the size and shape of the orebody and nature of the mining floor, makes possible the most economical development and extraction of the deposits. Because the profit margin is shrinking as the larger and richer orebodies are mined out, geology must be used to prolong the life of the district. Work of this type will undoubtedly be needed increasingly in other areas as well.

Cooperation between geologist, mining engineer, and metallurgist formed the theme of a symposium held in Salt Lake City. Too frequently the geologist and metallurgist are unfamiliar with each other's problems or the ways in which they can be of mutual assistance in planning successful exploitation of a deposit. Reno Sales warned: "The mining industry must awaken to the fact that research may mean its salvation, not only as an offset to increasing costs but as a measure for adding to reserves of ore." Unquestionably more research can and should be carried out, but the record of 1956 indicates that by and large all members of the profession are pushing ahead to meet the insatiable requirements of expanding U.S. economy.

Annual Review

Geochemistry and Geophysics in 1956

by Ralph C. Holmer

IN the field of mineral exploration, 1956 can be looked upon as the International Geochemical Year. This is not because of unusual developments in geochemical prospecting but rather because of the world-wide effort in geochemistry and the realization that geochemistry is now an established exploration method.

Use of mining geophysics has continued to increase. Those extensively employing exploration techniques indicate that developments of the past few years have permitted better programming of methods, from reconnaissance to location of drillholes. There is greater diversification of methods—reliance is not placed on results of one. However, it is realized that often it is more economical to drill an anomaly than to conduct additional expensive geophysical surveys.

In exploration it has been found that geophysics and geochemistry are not in competition with each other but, rather, offer supplemental information. Where large areas are being prospected, reconnaissance geochemistry is often used to narrow the target for airborne and ground geophysical surveys.

There has been a definite trend toward smaller geophysical equipment. Component parts are being made in plug-in units so that repairs in the field are made by progressively replacing units with spares until the equipment is operable. This plan results in the greater field use of nontechnical help and alleviates the technical manpower shortage.

Similar trends are present in geochemistry. Numerous simple and cheap chemical tests have been devised for direct use in the field. Some of these can be quickly taught to a practical prospector. Because of the prospector's resourcefulness, it is anticipated that a geochemical kit soon will be a standard piece of his equipment.

The year 1956 saw a decrease in the number of geophysicists graduating from North American universities. Fortunately, this does not indicate a trend, as most schools anticipate a substantial increase in 1957 and report more than normal interest among undergraduates. Educational facilities are increasing and curricula are expanding. Instructor and student interest in the mining phase of geophysics is increasing directly with the increase in development and use of mining geophysics. To the credit of our universities, the general feeling is that geophysics graduates are well trained. The only complaint is that there are not enough.

While there is little, if any, fundamental research being conducted with the development of exploration techniques specifically in mind, most larger organizations are involved to some degree in applied research and instrument development. In geophysics, nuclear resonance, magneto-tellurics, and induced polarization are currently being investigated. In geochemistry isotope study is exciting interest and investigation.

Education in geochemistry has been more limited, but because of existing school chemical laboratories and equipment and because of the economical field equipment and reagents required, academic activities in this field are beginning to show a spectacular increase.

Geographical Survey

According to H. G. Patrick, who reported on geophysical activity in 1955 at the 1956 annual meeting of the **Society of Exploration Geophysicists,** Canada led the countries of the world in expenditures for mining geophysics—some 40 pct of the world's total of $7.1 million. This is contrasted with 20 pct for the U. S., 18 pct for Europe and the Mediterranean area, 12 pct for Australia, 6 pct for Africa, 2 pct for Asia, and 2 pct for South America. By all indications, expenditures in 1956 exceed those of 1955, with proportionate expenditures by country approximately the same as in 1955.

Popular Canadian mining weeklies such as the *Northern Miner* indicate that geophysics has con-

Sikorsky S-55 equipped with electromagnetic, magnetic, and scintillation instruments illustrates trend to multiple recording of data during single flight. Companies with extensive exploration programs conduct some of the work themselves, particularly experimental surveys.

tinued to be used extensively in Canada. Because of the availability of excellent contracting services, smaller operators do not have geophysical staffs. While companies conducting extensive exploration programs do some of the work themselves, particularly the experimental type of survey, routine surveys are often contracted. With the exception of **International Nickel**, **Rio Tinto**, and **American Metals,** which have their own equipment, all companies contract airborne electromagnetic surveys. While fixed-wing airborne electromagnetic surveys have been available through **Aeromagnetic Surveys Ltd.** and **Lundberg Explorations Ltd.**, during 1956 **Aerophysics of Canada Ltd. (McPhar)** and **ABEM of Canada** also made equipment available on a contract basis. In addition, contract helicopter-borne electromagnetic service was made available by **Aeromagnetic Surveys Ltd.** and **Canadian Aero Services Ltd.**

Canada

Government Surveys: L. W. Morley reports that during 1956 the **Geological Survey of Canada** continued its program of aeromagnetic mapping. Four areas were flown: southwest New Brunswick, northern Manitoba, southern Nova Scotia, and a large circular feature about 100 miles northwest of Flin Flon, Manitoba, believed to be a meteoric crater. It is estimated that over the past seven years, government aeromagnetic surveys represented about 20 pct of all those conducted in Canada.

Approximately 30,000 line miles were flown in northern Manitoba, between latitudes 50° and 59° North and extending in a westerly direction from Hudson Bay to longitude 100° West. This is a Pre-Cambrian area where no geological mapping has been done. From a preliminary study of the data, it is apparent that an anomalous band about 20 miles wide crosses the central part of the area, striking in a northeasterly direction.

About 7000 line miles were flown in the southern and southwestern part of New Brunswick, centered on the city of St. John.

In Nova Scotia, the survey is still in progress but it is hoped to fly all the land area south of 44°30′ North. This essentially will complete aeromagnetic coverage of the province. Approximately the northeastern four-fifths has been covered by aeromagnetic surveys conducted by private companies.

A start has been made on routine quantitative interpretation of the numerous aeromagnetic maps the Geological Survey has been publishing.

During 1956 an airborne magnetometer and scintillometer survey was carried out—under the direction of the **Ontario Department of Mines**—of an area of about 640 square miles in the vicinity of **Bruce Mines**

About the Review

Some 291 questionnaires concerning the use of geophysics and geochemistry in 1956 were mailed to all parts of the world. About 97 replies were received. Unfortunately, this review is not a comprehensive report of world-wide geophysical and geochemical use. It is based entirely on the reports of those able and willing to contribute and on the observations of the contributor. As the report was compiled it became obvious that a number of important users of exploration methods had not been contacted. This is regrettable and can be corrected if interested contributors will let their identity be known. While many of the replies were short answers to the questions, some were descriptive and directly usable word-by-word in whole or in part in this summary. In the account of surveys, conclusions reached, and results obtained, the compiler takes no credit.

Because of the geographical nature of the replies, it was decided to make the division of the account of geophysical and geochemical surveys accordingly. Also, because of the frequent use of more than one method on a particular exploration problem, it no longer seemed appropriate to divide the accounts by method. However, separate divisions are made for Research and Education, two very important and related aspects of exploration that transcend geographical boundaries.

Surveys of governmental agencies are usually of a regional type. However, occasional detailed surveys are made. Rather than differentiate the objective of the survey, these are included under Government Surveys.

on the north shore of Lake Huron. Maps may be obtained from the Publications Branch of the department.

A **Geological Survey of Canada** ground party doing experimental electromagnetic work of the dip-angle type investigated the possibility of detecting pinnacle reefs in the Paleozoic section of southwestern Ontario. Considerable interference was encountered from power lines and wire fences, and it was possible to outline clearly only one pinnacle reef out of five investigated. This one reef was more easily outlined because of the lack of interference and because of its shallow depth—350 ft. No success was obtained in detecting the presence of faults.

R. W. Boyle reports that during 1956 the **Geological Survey of Canada** carried out research in geochemical prospecting in two field areas in Canada, and laboratory work was continued in the geochemical laboratories in Ottawa. Geochemical research on ore genesis and isotope geology was also continued.

In Nova Scotia stream water and stream sediments were tested for heavy metals in the area west of a line drawn from Lunenburg to Windsor. In Manitoba geochemical research was done on stream water in the Schist Lake area. Results of the two programs have not yet been analyzed in detail. Preliminary work has been started in dispersion characteristics of tin and tungsten from certain deposits in the Yukon.

In the laboratory further work has been done on dispersion of lead, zinc, copper, and silver from the lead-zinc-silver deposits of Keno Hill. Numerous samples of soil from this area have been analyzed quantitatively by spectrograph, and preliminary results suggest that the spectrograph can be used effectively for pedogeochemical prospecting. With regard to lead content in soils, results from spectrographic analyses follow closely those obtained by analytical methods using dithizone. It is also apparent that silver may be used as an indicator in pedogeochemical prospecting for lead-silver lodes in the Keno Hill-Galena Hill area.

Work has been continued on the effects of certain organic compounds such as the hydrogen saturated colloids (humic acid) in the transport of heavy metals in water and their fixation in soils. These organic compounds often cause difficulties in rapid geochemical methods of analysis using dithizone, and it is thought that a better knowledge of these compounds may alleviate some of the difficulties encountered in geochemical prospecting in muskeg areas.

Commercial Surveys: It has been noted that in eastern Canada generally, soil analysis is not being used in exploration as widely as a year ago because of difficulties that have arisen in interpreting anomalies appearing in transported glacial cover. However, in both eastern and central Canada, analysis of stream sediments is on the increase both for broad reconnaissance and for appraisal of individual mining properties.

At the **International Geologic Congress** in Mexico City, H. Bloom, J. S. Webb, H. E. Hawkes, and J. E. Riddell reported in "Geochemical Reconnaissance in Eastern Canada" that in 1954 and 1955 an area of 27,000 sq miles in New Brunswick and the Gaspé Peninsula was explored for base metal deposits by a reconnaissance method based on analysis of stream sediments for readily extractable heavy metals. About 15,000 sediment samples, representing more than 4900 sample sites, were collected and analyzed. The regional pattern obtained clearly outlined terrains with geochemical favorable characteristics for the occurrence of base metal deposits and located specific drainage areas of outstanding promise. Detailed investigation of such drainage areas led to the delineation of 43 local geochemical anomalies, of which the nine most promising were designated for intensive physical exploration. To date four of these have been drilled, and in each case evidence of significant base-metal mineralization has been disclosed.

A new Canadian-developed electromagnetometer, towed by a helicopter in flight, is now being introduced in precipitous mining terrain.

Lundberg Explorations Ltd. conducted air and/or ground surveys in Saskatchewan, Manitoba, Ontario, Quebec, and Nova Scotia. An extensive airborne magnetic survey in the area surrounding a large magnetite body failed to locate other bodies of similar character, demonstrating that potentially favorable prospecting ground can be examined quickly and at a very low cost by airborne surveys. In another area considered favorable for the occurrence of sulfide mineralization airborne electromagnetic surveys gave negative results. Diamond drilling based on an airborne magnetic survey of the Belcher Islands in Hudson Bay has indicated more than 400 million tons of 30+ pct magnetite. The magnetic intensity obtained over the sub-outcrop of these magnetic beds was not very great. This is due to the low dip of the beds.

Typical of the larger companies, **Kennco Explorations (Canada) Ltd.** in its search for base metals utilized the following geophysical methods: airborne magnetic and electromagnetic, and ground magnetic, electromagnetic, and self-potential. Geochemical surveys were also conducted, and geochemical and geophysical results were correlated. Surveys were conducted in the Bathurst-Newcastle area of New Brunswick, in the Eastern Township of Quebec, and in Highland Valley of British Columbia. The general procedure of exploration has been to conduct reconnaissance airborne electromagnetic and magnetic surveys over areas of several hundred square miles in what is considered to

be a geologically favorable region as determined by mineral occurrences or by interpretation of available geologic or aeromagnetic data, regional geochemical surveys, or aerial photographs. Where possible, anomalies of interest were located and tested on the ground by a combination of methods. Drilling revealed some graphite occurrences but numerous unknown sulfide occurrences were located, some of which may prove to be economic. In many cases it was found that the electromagnetic response of graphite was similar and in a few cases identical to that of massive sulfides. A certain amount of success has been attained in identifying the difference between the two responses.

United States

The use of geophysics and geochemistry in the U. S. has, in general, been restricted to the larger mining companies, which now have geophysicists on their staffs. Lack of demand has discouraged formation of contracting companies, and the use of geophysical and geochemical methods remains obscure to the smaller operator.

Most companies actively engaged in exploration do their own ground geophysical and geochemical surveys but on occasion have found a need for assistance. This has stimulated the formation of two active contracting groups, **United Geophysical Corp.** at Tucson and **McPhar Geophysics Inc.** at Minneapolis. Such service will be an aid not only to those actively engaged in exploration surveys but also to those who have an occasional exploration problem and are not equipped to handle it.

Contrasted with ground techniques, airborne geophysical methods continue to be the realm of the contractor. Most exploration companies do not wish to become involved with the operation of aircraft nor do they wish to commit themselves to exploration of the great areas that would be covered by continuous operation.

Airborne magnetometer surveys continue to be offered by **Aero Service Corp., Fairchild Aerial Surveys Inc.,** and **Hycon Aerial Surveys Inc.** Fixed-wing electromagnetic surveys were conducted by Hycon. It has been reported that McPhar Geophysics also will be prepared to offer this type of service. Hycon and Aero Service report the availability of helicopter-borne electromagnetic equipment.

U. S. Geological Survey—Geophysics Branch: L. C. Pakiser reported for the Geophysics Branch. Two aircraft were used during 1956 in making airborne magnetic and radioactive surveys. Of 55,000 traverse miles flown, approximately half were flown primarily for magnetic data and half for radioactivity data. Regional aeromagnetic and gravity studies are being made of the Colorado Plateau as a part of a study of the regional geology and its possible relationship to occurrence of uranium. Geothermal measurements are also being made to permit comparison of thermal gradients and heat flow in various parts of the Plateau with those in other geologic provinces. Aeromagnetic data have been used to prepare a basement contour map of Indiana. Magnetic and gravity studies of the regional geology of the Cuyuna Range have been in progress for some time. A systematic study is being made of the magnetic properties of the iron formation and related rock units. Regional gravity studies are being made in the western Mojave Desert and the Death, Panamint, Owens, and Long Valley areas in California. In Utah gravity field work has been done in the Weber Basin, Ogden Valley, and Salt Lake Valley. A brief gravity survey was done in Crescent Valley, Nevada. Major basin and range structures are clearly revealed by the gravity minima associated with thick accumulations of Cenozoic valley fill, and pediment areas of shallow bedrock are clearly revealed by gravity fields much higher than those associated with the deep basins. A gravity study is being made of the crustal structure and isostatic compensation of the Sierra Nevada Range. Results indicate that the crust may thicken to about 60 km west of the Sierra crest.

Seismic refraction and resistivity studies of depth to bedrock were done in a number of areas. Conventional geophysical methods have been used to solve many geologic, engineering, and ground water problems. Gravity, seismic, and electrical surveys have been used to study the geology of uranium in the Crooks Gap and the Gas Hills areas, Wyoming, the Monument Valley area, Arizona and Utah, and the Black Hills, South Dakota. Combined seismic refraction and resistivity surveys have proved to be useful in exploring for mineralized channels in the Monument Valley area. Gamma-ray logging is a routine service in studies of uranium geology. A program of gravity exploration for chromite ore in the Camaguey province of Cuba was completed in June. About ¼ million tons of refractory grade chromite ore was discovered as a result of drilling on gravity anomalies. Because of extremely detailed and precise gravity measurements, the probable error of a single gravity observation was held to 0.008 milligals or less. Gravity anomalies as small as 0.05 milligals were considered to be significant.

Work has continued in the development of seismic and acoustic, electrical, and radioactivity methods and instruments, with particular emphasis on problems of mining geology. Tests of the shallow reflection seismograph are continuing, and a nonexplosive source for exciting high-frequency seismic energy has been designed. A field and laboratory study of the possibilities of using Sonar for solving problems of shallow velocity layering has been started. The Boliden, Enslin, and Turam electromagnetic methods have been used in a number of problems in the Monument Valley, southern Arizona, and the iron ranges of Minnesota, with generally promising results. Electromagnetic anomalies in a channel area in the Monument Valley correlate with the position of one known channel over the entire length of the channel. They correlate over portions of two channels. Correlation with a fourth channel was negative. Radio signal strength has been correlated with near-surface geology in Minnesota. An experimental model of a new type of alpha logger was built and tested by the Radiation Laboratory in Denver, and a new *time interval differentiator* was designed and built for isotope identification. Development of a small-diameter acoustic logger was started.

U. S. Geological Survey—Geochemical Exploration Section: F. C. Canney reports that hydrogeochemical techniques of prospecting for uranium were used in Karnes County, Texas. In one part of the district the work located an orebody then unknown. Two mineralized faults were found, and favorable ground was delimited that later proved to be mineralized. In another part of the district that was ruled out by hydrogeochemical work as unlikely to contain ore deposits, physical exploration on a radiometric high found no ore and verified the geochemical appraisal. Descriptions of methods for determining uranium and bismuth in soils and rock and for uranium in water will be published in the near future.

An investigation of soil contamination by smelter fumes was made in the Coeur d'Alene district. It was found that the surface soils within a radius of several miles of the smelters were badly contaminated with lead and zinc, although most of the contamination was confined to the upper 6 in. of the soil profile. The data of this study, which were released as an open file report, should serve as a warning to any geochemical prospector working in a district containing a smelter.

Currently the Section is working on the development of methods for mercury and tantalum in soils and rocks, and for uranium in vegetation. The method for uranium, which involves ashing in the field, is essentially complete. The method for mercury shows promise and should detect as little as one half part per million. The tantalum method is a minor modification of the British chromatographic technique. A one-piece still has been devised for use in a rapid field determination of selenium. This method, which will detect as little as 10 ppm, was designed primarily as a prospect evaluation tool.

Atomic Energy Commission—Geophysical Research and Development Branch: M. E. Denson reports that Branch activities in the field and in the laboratory have been to attempt to improve techniques or develop methods of geophysics and geochemistry for radioactive mineral exploration.

Analysis of natural waters for uranium content has been used primarily to explore unfamiliar areas for dispersion halos and to trace increases in uranium concentrations along courses upstream to the source. In an area northwest of Spokane, Wash., results confirmed that concentration anomalies found in water coincided with locations of known uranium deposits. However, areas lacking indications of anomalous values of uranium in natural waters may be of more interest than the water analyses would indicate. If seasonal or other factors cause the water to be slightly acidic (below pH 6.5) or if the bicarbonate ion concentration is low, anomalous values of uranium will not occur. New areas of anomalous waters may or may not be significant, depending upon the chemistry and kind of water as well as the background values of the country rock. For example, high bicarbonate ion concentration may cause solubilization of uranium from large low grade disseminated deposits. A correlation index between stream waters and stream sediments is needed, as some areas lack sufficient water for adequate surveys.

In an area near Edgemont, S. D., geochemical soil analysis has been used in conjunction with surface resistivity measurements to outline the course of a buried stream channel. Anomalous soil concentrations of uranium did not correlate with drillhole data. A good correlation was found in one area between cores of sulfide and uranium mineralization and surface resistivity measurements using a variable frequency method. In the same area a dry hole electric logging method, utilizing saturated sponge-rubber electrodes, correlated with radioactivity logs and core information.

U. S. Geological Survey—Ground Water Branch: A. G. Fiedler reports that the application of geophysics to ground water exploration has increased substantially in recent years, principally because of the availability of portable well-logging units and the greater recognition that electric and radioactive logging provides valuable information on the thickness and areal extent of water-bearing formations and the chemical quality of the water contained in them. A paper by W. O. Smith entitled "Recent Under-water Developments Using Low-Frequency Sound to Locate Shallow Bedrock" probably will be published next year by the Geological Society of America.

U. S. Bureau of Public Roads: R. W. Moore states that as of Dec. 31, 1956, geophysical methods have been employed in more than 40 of the 48 states in connection with highway construction and other engineering work. As in past years the geophysical activity has, for the most part, been limited to use of the earth-resistivity test procedure, although at least five states also are making use of the refraction seismic test. During the past 12 months the U. S. Bureau of Public Roads has engaged in geophysical studies and demonstration tests in eight states and in Hawaii. There are now 27 state highway departments which either have geophysical equipment or a cooperative arrangement with some other agency within the state for the use of such equipment. Interest has been expressed by ten other states in the application of geophysical methods to future subsurface explorations.

The geophysical work in the **U. S. Bureau of Public Roads** continues to expand. Eight resistivity units are now available for work in the field. **The Inter-American Highway Office** is making use of both refraction seismic and resistivity methods to good advantage. Consulting engineering firms are showing increasing interest in the use of the geophysical tests, and this interest should increase under the impact of the expanded highway construction program now under way.

State Governments: California is supplying some funds for cooperative geophysical work with the USGS, specifically that dealing with the investigations in Long Valley and Owens Valley, California. George Cleveland, of the Division of Mines, and Donald Carlisle, of the University of California at Los Angeles, have completed a paper for publication by the Division of Mines dealing with the geochemistry of California molybdenum samples.

The **Illinois State Geological Survey** continued its earth resistivity program for locating subsurface deposits of water-bearing sand and gravel from which water supplies could be obtained for industries, cities, and farms. Results were highly satisfactory; 51 surveys were planned and completed this season. Shallow refraction seismograph surveys were made to obtain further information on bedrock topography and drift lithology in areas of buried bedrock valleys in Winnebago, Ogle, Mason, Menard, and Casa counties.

The **Geophysics Section** of the **Indiana Geological Survey** used seismic refraction and reflection techniques to provide information about coal reserves. Bedrock topography was mapped in detail and checked by test holes. Preglacial drainage lines were mapped and the amount of coal that had been eroded by this drainage has been computed. Seismic refraction techniques were used to determine thickness of cover at dam and large building sites. The instrument and development program has been concerned mainly with electrical measurements in the field, and the development of suitable instruments to measure the physical properties of earth materials in the laboratory. Use is being made of Indiana University's High-Speed Digital Computer for the solution and analysis of field data. Preparations are being made for the solution of complex theoretical problems by means of a small analog computer.

At the annual meeting of the **Geological Society of America,** G. D. Bath and G. M. Schwartz presented "Regional Aeromagnetic Study of the Mesabi District, Minnesota." They reported that aeromagnetic maps of the Mesabi district, published by the USGS, show regional magnetic trends that can be correlated with the positions of magnetite-rich members within the Biwabik iron formation. Magnetic lows are correlated with the position of major oxidized areas of the mines. Over the westernmost Mesabi, the rock magnetization decreases as both the thickness and the magnetic-iron content of the cherty members diminish westward. Interpretations indicate that magnetic members within the Biwabik extend for some distance down dip from exposures in the open pit mines. A part of the eastern Mesabi is magnetized in a direction at variance to the earth's magnetic field and gives pronounced negative anomalies.

In 1955 the **Missouri Geological Survey** initiated a one-party two-year resistivity program for ground water in northern Missouri. Members of the Survey believe that the method is useful as a supplement to test drilling in locating and mapping preglacial or interglacial drift-filled valleys. It has been observed

that the best source of potable water is in the thick drift deposits.

In August 1956 the **Montana Bureau of Mines and Geology** published "Geochemical Prospecting by Soil Analyses in Montana" by Forbes Robertson. Soil sampling was conducted in 20 mining districts over a wide variety of deposits in many kinds of rocks. Principal attention was paid to lead and zinc deposits in fissure veins and replacement deposits in limestones. Three different tungsten occurrences were tested, along with two copper deposits and several gold-silver deposits, several of which contain arsenic.

Best geochemical indications are obtained in soils over fissure veins and replacement lodes in limestones and dolomites. Good indications are obtained from fissure veins which contain known ore in many different types of rocks, including volcanic and granitic igneous rocks, metamorphic rocks, and a variety of sedimentary rocks. Less conclusive results are obtained over some veins in andesitic rocks. Metals from commercial ore shoots frequently are not detected more than 100 to 200 ft down the slope. However, the major mining districts usually show a high metal content over a wide area.

As a result of finding significant quantities of pyrrhotite in a water well drilled in southeastern New Hampshire, and also as a result of an aeromagnetic test flight over the area in 1954, the **Planning and Development Commission of the State of New Hampshire** and the USGS have undertaken a cooperative airborne geophysical survey of portions of New Hampshire of past or potential mineral production. Begun in 1955, the project is scheduled for completion by June 30, 1957. Flying, computing, and map preparation are done by the USGS. The first two maps resulting from this cooperative survey were released in October 1956—the Alton Quadrangle, New Hampshire, and the Berwick Quadrangle, New Hampshire-Maine.

The **Division of Planning and Development** of the **Department of Conservation and Economic Development of the State of New Jersey** used the scintillometer and geiger counter to map radioactive belts of rock containing either uranium-bearing or thorium-bearing minerals. One or two areas show promise of developing a commercial source of uranium, and two bands of monazite-bearing rock have been mapped. Enough work has been done to demonstrate that there is an area north of Chester having a considerable thickness of sand which, at the surface at least, contains interesting amounts of heavy minerals, including ilmenite, monazite, and zircon. The Ringwood area was resurveyed by the airborne magnetometer. The USGS flew the Chester, Jenny Jump, and Ringwood areas with a scintillometer.

The **Department of Geology and Mineral Industries of the State of Oregon** did a minor amount of geobotanical work on the chromite-bearing areas of southwestern Oregon, but preliminary information was not encouraging so the program was dropped.

C.L. Whited at the **International Geological Congress** reported that direct-current resistivity for subsurface investigations in connection with the West Virginia Turnpike was employed to determine the amount of overburden and subsurface materials for cut sections and bridge sites. Approximately 80 bridge sites were investigated. Proposed rock cuts to depths of about 100 ft were examined throughout the 88-mile length of the roadway. An appreciable saving was effected by reducing the amount of drilling normally needed.

Commercial Surveys: Jones & Laughlin Steel Corp. has added a geophysicist to its exploration staff. During the past year this corporation has been actively engaged with ground magnetics and gravity in the search for iron ore, especially magnetic taconite, in northern Wisconsin and Minnesota and in Quebec and Ontario. The surveys were successful in outlining details of previously discovered magnetic anomalies and formed a basis for projecting possible ore trends into nonmagnetic areas. Favorable areas for drilling were outlined. A new miniature self-potential unit has been developed.

Columbia-Geneva Steel, in exploring for iron ore in the western states and Alaska, conducted ground and airborne magnetic and gravity surveys. In general these surveys followed reconnaissance geologic examination and resulted in economic discoveries. There is a trend toward research in remanent magnetization and methods for measuring it. This is important in prospecting for those taconites that give high magnetic anomalies.

St. Joseph Lead Co. utilized gravity, magnetic, resistivity and Radore, radiometric, and geochemical methods in exploration for lead, zinc, iron, copper, and manganese, mainly in southeastern Missouri. These methods were helpful in selecting areas for exploratory drilling, and there is increasing dependence on these aids. Temperature measurements are now being made in drillholes.

At the annual meeting of the **Geological Society of America,** F. D. Eckelmann, J. L. Kulp, and J. S. Brown reported on "Lead Isotopes and the Pattern of Mineralization in Southeast Missouri." Lead-isotopic analyses of all 150 samples collected in the Lead Belt show excess radiogenic lead over average crustal lead. Variations in lead-isotope composition, along structures known to have affected migration of ore solutions, indicate that the earliest mineralizing solutions contained maximum amounts of radiogenic lead as compared to solutions responsible for later phases of mineralization. This parameter is used to determine the pattern of mineralization in areas where the controlling geologic features are less obvious.

In the search for base metals, the **Bear Creek Mining Co.** utilized the standard techniques of airborne and ground geophysical methods. In addition, helicopter-borne electromagnetic and induced polarization equipment were in operation. During 1956 geophysical work was done in 15 localities in nine states. Considerable geochemical work, primarily of a reconnaissance nature, also was done. In one particular instance it was used to guide more detailed airborne and ground geophysical surveys to interesting but as yet untested prospects.

The principal difficulties of differentiating graphite, barren sulfides, and commercial grade sulfides remain. It has been observed that in some cases the differentiation of the first from the latter two can be interpreted, but in general, the most economic and definitive step is to drill early indications and omit expensive detailed geophysical work. Considerable sulfide material has been drilled, the drilling based on interpretation of geophysical data. In general the sulfides have been barren or near-barren, but the applicability of geophysical methods to the location of near-surface sulfides has been established.

Phelps Dodge Corp. conducted ground magnetic, resistivity, gravity, and radiometric surveys in exploration for copper and uranium in the western portion of the U. S.

Newmont Explorations, Ltd., in its base metal exploration program in Canada, South Africa, and the U. S., utilized overvoltage (induced polarization), low frequency electromagnetic, magnetic, and geochemical methods. In cooperation with **Aero Service Corp.,** an electromagnetic device rigidly attached to a Sikorsky S-55 helicopter, containing a Gulf-type magnetometer and a scintillometer, has been put into satisfactory operation. A preliminary short-spaced ground detailing electromagnetic instrument has been built and is being tested.

Sherwin F. Kelly reports the successful application of resistivity measurements to the outlining of zones of pyrophyllite mineralization in the southern Appalachian region.

Leroy Scharon reports that he has been associated with magnetic surveys in New York State for the purpose of locating titaniferous magnetite deposits, in

Tennessee for magnetic materials associated with barite, and southeast Missouri for the purpose of mapping the topography of the Pre-Cambrian basement complex. This latter project is carried out for the purpose of delineating structural features in the overlying sediments which are favorable for lead occurrences.

Miami Copper Co. conducted a radiometric survey for uranium on a limited area in Gila County, Arizona, outlining three small anomalies.

Lundberg Explorations Ltd. reports that areas in California, Utah, Illinois, Tennessee, North Carolina, and Virginia were surveyed by the ground and airborne electromagnetic methods and by the airborne scintillometer.

In the first three quarters of 1956, **Fairchild Aerial Surveys** has performed these airborne magnetometer surveys for mining exploration: Arizona, 2668 profile miles; California, 431 profile miles; Canada, 3937 profile miles; South Dakota, 1600 profile miles; Wyoming, 600 profile miles—a total of 9236 profile miles.

W. H. Straley submitted information concerning ground magnetic and radiation surveys performed by seven parties over a period of five months in the middle and southeastern states. Ten or twelve new orebodies were located.

Mexico

The people of Mexico are to be congratulated for their outstanding program at the **International Geologic Congress** held in Mexico City in September. A number of papers of interest to explorationists were presented. The symposium on geochemistry was particularly comprehensive, and by its content of 62 papers from 15 different countries served to call attention to the world-wide interest and activity in applying geochemistry to prospecting and to the study of ore genesis. Organized by T. S. Lovering of the **Geochemical Exploration Section** of the **USGS**, the symposium was the first of its kind ever presented. Abstracts of all papers were distributed at the Congress. A volume containing the full texts is to be published in 1957.

Central America

The **Industrial Development Corp.** of the Government of Jamaica, B.W.I., continued ground magnetic work in structural studies and the search for iron ore deposits; resistivity surveys with the use of a Megger were undertaken to assist in an extensive investigation of ceramic clay deposits and in ground water investigations; and radiometric surveys were conducted. The ground magnetic work was primarily directed toward investigation of anomalies previously located by airborne magnetometer. A number of hematite veins were located, some of which may prove to be of economic value. The work is being continued. The resistivity surveys in the investigation of ceramic clay deposits were successful in locating appreciable quantities of good quality alluvial clay. Fairly accurate quantity estimates were made which helped in the final evaluation of the deposits. In addition to routine radiometric prospecting, a special investigation of the Island's radioactive springs was undertaken and is being continued. With the use of simple field radiation-detecting equipment, a technique was developed to obtain radioactive decay curves, from which it was possible to determine the presence of certain radioactive minerals in the water. The resistivity method is used in the routine prospecting for ground water, which is an important asset to the Island's irrigation.

Sherwin F. Kelly reports considerable work in Cuba, Panama, Guatemala, and Honduras. The work has been largely by electrical techniques—spontaneous polarization and resistivity—both on commercial contracts and in field research on the applicability of these methods to relatively new problems. The results of the research suggest that geophysics can be more widely applied in the industrial mineral field than has yet been realized.

In Cuba, near Matanzas and near Pinar del Rio in the northern part of the Island, spontaneous polarization and resistivity were utilized in the search for copper ores. Copper was also the objective in some work in Panama. In Honduras, exploration was conducted on lead-zinc ores. Numerous surveys were carried out in Guatemala on metallic and nonmetallic mineral deposits. Resistivity and spontaneous polarization were employed jointly in tackling the exploration for lead-zinc ores, as was done in Honduras. The Guatemalan deposits, like the Honduran ones, are in limestone and carry a substantial percentage of nonconductive sphalerite. Resistivity observations were used to map major fault patterns where faulting was important either in controlling the loci of deposition or in subsequently displacing the deposits. Some preliminary reconnaissance was carried out in what may prove to be a new copper-bearing zone in western Guatemala.

Research was conducted on the applicability of resistivity methods to the exploration for volcanic sulfur at Volcan Tecuamburro, south of Guatemala City. Strong anomalies were observed both on sulfur impregnations in tuffs and pumices around the crater itself, and on sulfur springs at the base of the extinct volcano. A large area of potential sulfur-bearing material was subsequently indicated by a resistivity survey. Another project of field research produced an unexpectedly favorable result on stibnite in the Department of Huehuetenango in western Guatemala. This mineral is electrically nonconductive, but distinctive spontaneous polarization anomalies were observed on known veins of this sulfide. The observed phenomenon is tentatively ascribed to associated faulting and the probable occurrence of minor quantities of conductive sulfides in the shale and limestone wall rocks and in the fault zones. Some new veins were geophysically indicated and subsequently opened up, and the property is now going into production.

In Honduras a resistivity survey was effected on a proposed mine-drainage tunnel alignment some 4 kilometers long. The survey was to measure the thickness of shales overlying massive limestone to determine whether or not the tunnel would encounter the shale and where faulted zones of major importance might be expected. This required extending the measurements to depths as great as 1000 ft in a wooded mountainous terrain.

South America

In Venezuela extensive airborne scintillation and magnetic surveys were carried out by **Lundberg Explorations Ltd.** The airborne-vertical component

The transmitting coil of this electromagnetic system is fixed to one end of a 20-ft bird, which is towed at a constant height over the ground, and the receiving coil to the other.

Electromagnetic prospecting in Maine. Considerable improvement has been made in decreasing costs and increasing versatility of this equipment.

magnetic surveys, made in the vicinity of the 7th parallel of latitude, recorded stronger positive anomalies over hematite orebodies than were accountable from the magnetite content. By obtaining data at different altitudes, it was possible to make calculations showing that the hematite ore rested on magnetite-rich quartzites having a considerable extension to depth.

In British Guiana in the vicinity of the Pomeroon and Supenaam Rivers, the airborne magnetometer was utilized in bauxite exploration. Fault and dike anomalies were noted and the depth of unconsolidated rock to basement was determined. In Surinam aeromagnetic surveys were conducted for the **Aluminum Co. of America** and for the **Billiton Co.**

Nobel Munoz has continued to conduct resistivity surveys for fresh water in western Buenos Aires Province and northern Santa Fe Province for ranch use, as well as near the city of Buenos Aires for industrial use.

Europe

Hunting Geophysics Ltd. of London operates with the same airborne magnetic, electromagnetic, and scintillation equipment as its associated company, **Aeromagnetic Surveys Ltd.** of Toronto. **Hunting** is prepared to conduct photographic and geophysical airborne and ground surveys in Europe, Africa, Middle East, Far East, the Antarctic, and Australasia. It is understood that airborne service and ground geophysical service and instruments are available from **A/B Elektrisk Malmletning** of Stockholm and that ground equipment is available from **Hilger Watts** of London and **Askania-Werke** of Berlin.

The Directorate of **Colonial Geological Surveys** has added a section to give assistance to Colonial territories in making geophysical surveys. It is equipped to make magnetic, gravity, electrical, and seismic refraction surveys. Its first assignment in 1956 was the investigation, with the **Geological Survey of Tanganyika,** of postulated buried alluvial channels in an auriferous field. Various anomalies were obtained but not yet evaluated.

The 12 months to Nov. 1, 1956, have shown a distinct increase of interest and activity in prospecting in Ireland, mainly for metalliferous minerals. This follows the leasing by the Government of the large **Avoca Co.** Wicklow copper deposits and the introduction of a revised tax code for new mining operations. Renewed prospecting has tended to concentrate first on the available surface and mine evidence on many old showings of the 1830 to 1880 mining period. **Silvermines Lead & Zinc Co.** announced early in 1956 that a geophysical survey was carried out over a portion of the property where sulfide lead ore occurs along and near faults between Devonian sandstone and Carboniferous limestones. Both gravity and resistivity traverses were run, and boreholes sited mainly on the resistivity anomalies were successful in intersecting extensions of galena ore. Since the summer of 1956 **St. Patrick's Copper Mines Ltd.,** at Avoca, has been carrying out experimental geochemical prospecting by methods involving sampling of both water and soils over a mineralized shear zone carrying mainly chalcopyrite and pyrite.

Geophysical work by the **Geological Survey of Ireland** was confined to a continuation of examination of outcrops and old mine dumps by hand-carried geiger counter. No radioactive anomalies were reported.

The **Geological Survey of Finland** conducted airborne and ground geophysical surveys, mainly for the purpose of ground prospecting. The airborne surveys involved simultaneous magnetic, electromagnetic, and radioactive measurements from an all-metal Lockheed Lodestar. Total area covered during 1956 was 18,000 sq kilometers. Taking into account the surveys of earlier years, 1951 to 1955, about one fifth of Finland has been covered by airborne surveys. Results obtained have been very valuable both for ore prospecting and geological mapping. Geophysical prospecting on the ground involved magnetic, Swedish *loop-frame* electromagnetic, resistivity, gravity, and radiometric surveys. Interest in ore prospecting has clearly increased during the year. There is a great demand for the airborne geophysical maps produced by the Geological Survey, and many companies have enlarged their prospecting activity accordingly. Among the geophysical methods, the radioactive method especially has become very popular during the year. Most of the geophysical work has been done by government institutes or government-owned companies, but the work of private companies also has been important and is continually increasing.

At the **International Geologic Congress** Martti Salmi of Finland reported strong patterns of titanium, vanadium, antimony, molybdenum, iron, and copper in organic muck overlying known deposits in the bedrock at depths from 1 to 10 meters. His data provided evidence that these elements dissolve and migrate in the anerobic, reducing environment beneath peat bogs.

Lundberg Explorations Ltd. reported that its three airborne methods—vertical component magnetic, electromagnetic, and scintillation—were used in surveys in Sweden, Finland, and France.

At the **International Geologic Congress** Fritz Persch reported that to explore the important German lignite resources of the Lower Rhine Basin several thousand boreholes have been drilled since 1948. The larger part of these holes were logged electrically and radioactively. It was found that as most of the lignite deposits below the water table contain humic acid, they are fairly conductive. If the lignite seams are intercalated between fresh-water sands, their upper and lower contacts are electrically well defined by the high resistivity of the sands. If, however, the lignite seams are overlain or underlain by clay, gamma-rays in connection with resistivity curves demonstrate a clear difference between these two formations. Sandy clay may show the same resistivity as lignite, but the potassium isotope, K_{40}, absorbed by clays emits gamma-rays, whereas lignite as an organic compound is generally inactive.

South Africa

Mineral Search of Africa (Private) Ltd., a wholly-owned subsidiary of **Rio Tinto Co. Ltd.,** London, reports extensive exploration in Southern and Northern Rhodesia, Southwest Africa, and the Union of South Africa. Both geochemistry and geophysics are an integral part of the company's exploration program. Geochemistry has become of considerable importance in areas covered by residual soils. All areas under investigation are covered by a program of soil sampling, employing continuously approximately 18 men, taking samples and running lines. Approximately 450 sq miles have been covered. Samples are analyzed for trace elements on Jarrell-Ash 1.5 meter Geological Survey type of grating spectrographs. Determinations for five metals are done per sample. Analysis output is 250 to 400 samples per day for each spectrograph. Ground geophysical surveys are carried out on areas of interest located by the geochemical survey or by geologists. Magnetic, gravity, resistivity, electromagnetic, self-potential, or radiometric methods are employed, depending upon the problem. An important aspect of the geophysical work has been that of obtaining local and regional structural information. Limits of ore zones prior to drilling and during drilling have been delineated. An area of 4000 sq miles was covered by aerial magnetometer and scintillometer using the company's own equipment and personnel. The company's policy is to cover large new areas with an aerial magnetic survey prior to starting surveys on the ground. An airborne electromagnetic unit has been designed and put into successful operation in conjunction with British and Canadian associates. At the moment research is confined to electromagnetic methods.

Anglo-American Corp. of South Africa Ltd. has been engaged in airborne and ground geophysical prospecting, mainly in Northern Rhodesia.

The primary problem of the **Geological Survey of the Gold Coast** is the provision of potable water supplies cheaply to widely scattered peoples. Three crews are continuing the resistivity surveys commenced some years ago. An attempt is in progress to apply statistical methods to the relationship between evaluated resistivity results and the success of locating water. Mineral investigations receive some attention and may receive more in the future. Self-potential work on possible copper-sulfide deposits is in progress. Magnetometer investigations are being conducted in the southern Gold Coast. One survey is on chromite deposits in serpentine where the susceptibility contrast between the chromite and serpentine appears to be small. Another survey is on a gabbro/greenstone contact where titaniferous magnetite and native gold prospects occur. Ratemeter work on monazite sands is being conducted. It is hoped that country-wide gravity and magnetic surveys will be initiated to shed light on structural and other problems.

The **Mines and Geological Department of Nairobi** reports that geochemical sampling was carried out near the Vitengeni lead mine and also at the coast. Results obtained are not yet available.

Turkey

In the eastern part of Turkey two parties used self-potential and resistivity methods in the search for copper. In one case a self-potential negative center of 250 mv was obtained where high resistivity values were measured. The ore consists of disseminated chalcopyrite and pyrite in a highly silicified volcanic rock. The high silica content was interpreted to be the cause of the high resistivity.

In one area in the western part of Turkey one party used resistivity and induced polarization in prospecting for lead. In another area one party used resistivity and high-frequency electromagnetic equipment on a lignite coal problem. Near-surface faults were located and the depths to the bottom of the coal seams were calculated. The tops of the coal seams were difficult to differentiate electrically from the overlying formations.

India

M. B. Ramachandra Rao reports that ten geophysical surveys were executed by the **Geological Survey of India** during 1956 in different parts of the country. Of these, three were in connection with exploration for oil, four for sulfide ores, one for tracing coal seams, one for auriferous lodes, one for ground-water studies, and the last one to locate a large steel hammer lost in riverbed sands during a flood.

Exploration for sulfide ores was carried out using self-potential, resistivity, and magnetic methods. In two of the areas examined, Mayurbhanj in Orissa and Agnigundala of Andhra State, the surveys did not reveal any important anomalies. In the other two areas, Khetri Copper Belt in Rajasthan and the Chitaldrug Belt of Mysore State, the systematic surveys have shown many promising anomaly zones.

The investigation by resistivity methods for tracing coal seams beyond fault zones at Corba did not meet with success. Although in a few instances the outcropping beds of coal showed high resistivity values, the electrical indications could not be followed up because of rapid variations in the electrical properties of the associated sandstones and shales and the overlying alluvium and laterite.

The magnetic and electrical surveys in the Kolar Gold Field area have shown some very interesting results. The magnetic anomalies were mostly connected with dolerites and amphibolites which carry appreciable amounts of magnetite. The self-potential surveys showed strong negative centers over a zone more than 2000 ft in length. These indications are presumably connected with graphitic schists occurring in this belt. Some self-potential anomalies also were found corresponding to some of the auriferous sulfide lodes known in the underground workings of the Nandydroog mine.

Geochemical surveys were carried out in portions of the Singhbhum Copper Belt.

Resistivity surveys were conducted in the Bijapur district with the object of locating marked depressions or deeply buried old valleys from which large supplies of water for irrigation could be tapped. The surveys failed to detect any such features.

The **Geological Survey** is proposing to extend systematic geophysical examinations to all the mineralized belts in the country. In the Second Five Year Plan period, a coordinated program has been drawn up for detailed geologic mapping, systematic geophysical and geochemical prospecting, and drilling. A research laboratory for geophysical studies is proposed.

The Engineering Research Station of the **Central Water and Power Commission** of the **Government of India** has a geophysical party that carries on investigations of dam and bridge sites for the engineering projects of the States and the Union Government.

Federation of Malaya

The **Geological Survey of the Federation of Malaya** is making plans for a 16,000-sq mile combined aeromagnetic and radiometric survey of parts of Malaya through financial assistance provided by the Canadian Government under the Colombo Plan. It is anticipated that the survey will be started in late 1956, or in 1957, and will take three or four months.

Australia

P. B. Nye, Director of the **Bureau of Mineral Resources, Geology and Geophysics,** reports that during 1956 the trend towards large-scale projects continued. Airborne and seismic techniques in the search for uranium and oil respectively were the main geophysical techniques used. Most of the other standard geophysical and geochemical methods also were used for a variety of objectives. In all cases personnel of the Geophysical Section of the Bureau carried out the surveys.

At Gippsland, Victoria, an off-shore area of 9500 sq miles was flown to locate anomalies that may be associated with oil-bearing structures. At Nowa Nowa, Victoria, an area of 400 sq miles was flown to trace extensions of known iron ore deposits. Small areas totaling 360 sq miles were flown for a similar purpose in Tasmania at Rocky River, Nelson, Hampshire and Blyth River. An area of 130 sq miles near Cranbourne, Victoria, was flown to search for occurrences of near-surface basalt for quarrying purposes.

At Tennant Creek, Northern Territory, a detailed composite radiometric and magnetic survey was made of 2450 sq miles. In the Davenport Range area a reconnaissance survey was made of 8200 sq miles. In both these areas numerous radioactive anomalies were detected. In the Geraldton-Onslow region of Western Australia, an area of 22,000 sq miles was scanned as a composite survey. Several magnetic anomalies over a sedimentary basin present good prospects for the computation of the depth to basement. A significant change in the level of radioactive intensity at the contact between sedimentary and igneous rocks persisted throughout the region. Some prominent radioactive anomalies were detected. Near Southern Cross a composite survey was made over 6500 sq miles. Several magnetic anomalies due to banded iron formations were located. A few radiometric anomalies were located.

Airborne radiometric surveys were made of scattered areas in the Eastern Highland of Victoria and near Glen Innes, New South Wales, without detecting any localized occurrences of radioactivity. Three areas totaling 218 sq miles were flown near Mosquito Creek, Northern Territory, and 71 radioactive anomalies worthy of ground examination were detected. At Calvert Hills, on the Queensland-Northern Territory border, an area of 800 sq miles was surveyed. Several radioactive zones were detected. Ground parties equipped with vehicle-born scintillograph and odograph operated over extensive areas in the Northern Territory and in the Cloncurry District of Queensland. No radioactive occurrences of importance were discovered.

At the Glen Lyell and Corridor leases in the Mt. Lyell copper field, Tasmania, electromagnetic and self-potential surveys were made in the search for additional orebodies. The course of a tin-bearing deep lead was traced for 1½ miles at South Mt. Cameron, Tasmania, by seismic methods. A similar investigation was made on another tin-bearing deep lead at Ardlethan, New South Wales. In the vicinity of the Lady Evelyn mine, at Pine Creek, Northern Territory, electromagnetic, magnetic and self-potential surveys were made to trace extensions of a lead-zinc lode. At Nymagee, New South Wales, electromagnetic methods were applied to locate uranium-bearing fissures in the granites.

In the Gippsland brown coal fields, Victoria, two small areas were surveyed in detail by gravity methods. The survey produced valuable information on the general structure of the coal formations, revealed the localities of thickest deposits and shallow overburden, and was a main factor in the discovery of an important extension of the deposits of high grade brown coal.

Extensive gravity and seismic work was done in sedimentary basins to obtain regional structural information and to determine the thickness of the sedimentary section. The regional magnetic work was extended to large areas of Victoria and Queensland.

In the Cloncurry District geochemical prospecting for copper and lead followed detailed geological mapping. A series of dike-like bodies of quartz-hematite rock extending for over 12 miles, and several extensive limonite gossans, were sampled at 150-ft intervals. Two significant copper anomalies were defined in the quartz-hematite bodies. Soil and river gravel samples adjacent to the anomalies showed clearly that copper was being shed from the outcrop. The limonite gossans gave consistently high copper values throughout their length, with several short sections of anomalous concentration. Testing for lead in the area was confined to one stratigraphic horizon in the vicinity of a known low grade lead deposit, but no significant results were obtained. A number of samples of cobaltiferous soils were collected for testing and for development of the technique of prospecting for cobalt.

Geochemical prospecting for copper and lead was carried out in the Tennant Creek mineral field. Gridded soil testing over known copper orebodies and concealed magnetic anomalies gave erratic results, indicating that copper and lead are widely distributed throughout the soils in this area. Outcrop sampling of slates and quartz-hematite rocks along major lode lines proved more promising in that appreciable amounts of copper were detected. Results show a relatively high copper concentration in the quartz-hematite rocks (relative to the slates) rather than a sharply outlined geochemical anomaly. As economic copper deposits are known to occur in association with quartz-hematite outcrops in this area, these results may be significant.

Mount Isa Mines Ltd. carried out a regional geochemical survey for lead, zinc, and copper in the McArthur River area, Northern Territory. Spot tests were used in the field, and samples giving a positive reaction were bagged and sent back to base for further investigation.

Resistivity and seismic methods were used at Alice Springs, Northern Territory, to provide information on subsurface water-bearing formations along the course of the Todd River.

Shallow-reflection seismic equipment was successfully used in engineering investigations. Seismic and resistivity methods were used in obtaining bedrock profiles and other significant information at large engineering sites. The Great Lake North and Upper Repulse dam sites were surveyed. At Kiowa, Victoria, several dam and power station sites were surveyed. A number of bridge and dam sites were surveyed near Canberra.

Research

No specific lines of research have been reported by the mining companies. However, it is understood that instrument developments are being made in induced polarization and magneto-tellurics, and new applications of nuclear resonance are being investigated.

For more immediate gain, standard equipment is being redesigned and miniaturized to require less personnel in the field. By the use of plug-in units, repairs can be made quickly in the field by replacing defective units, thereby requiring less technically qualified field personnel. Several companies report development of drillhole logging units able to obtain data in slim drillholes.

Geophysical and geochemical research in the mining industry is generally restricted to development and improvement of exploration methods, techniques, and methods of interpretation based on fundamental research done elsewhere. At present such fundamental research is almost entirely confined to that done by government agencies, educational institutions, and the petroleum industry.

Because the petroleum industry was not contacted directly, no attempt is made to summarize its effort in research that may have significance in mineral exploration. However, it is sizable. Research resulting in drillhole techniques may be cited. New developments along this line that should be of interest were reported at the **Society of Exploration Geophysicists** annual meeting by M. B. Dobrin and H. F. Dunlap in a paper entitled "Geophysical Research and Progress in Exploration." To quote one brief entry in this paper: "Photomultiplier tubes and scintillation crystals have been developed for borehole use which can measure gamma-ray spectra. These make it possible to select only that radiation which is characteristic of a particular element or group of elements under investigation, thus enabling one to determine the chemical compositions of the formations penetrated by the borehole."

An announcement that an airborne gravity gradiometer has been invented by B. D. Boitnott of Houston, Texas, and successfully tested by **Lundberg Explorations Ltd.** has excited the interest of geophysicists who, in general, have felt that gravity measurements of sufficient accuracy for exploration use could not be made from an aircraft. A paper on this instrument is scheduled for presentation by Hans Lundberg at the AIME annual meeting in New Orleans in February 1957.

Attention is directed to a paper by D. S. Parasnis of Stockholm, Sweden, in the September 1956 issue of *Geophysical Prospecting*, the official journal of the **European Association of Exploration Geophysicists**, tabulating and discussing the resistivities of 286 sulfide and oxide ore samples and 7 samples of graphitic shales.

Research by Government Agencies

The National Science Foundation: The Advisory Committee for Mineral Research (James Boyd, Chairman) appointed by the **National Science Board** to make recommendations concerning research in the fields of geology, geophysics, and geochemistry, has made a thorough investigation and has submitted its report to the **National Science Foundation** (Alan T. Waterman, Director).

The Committee recommended the formation of a Minerals Research Institute, which should receive its general support from the mining industry and other private sources. The Committee requested, and was granted, authorization to explore these matters with representatives of the mining industry. The Committee, realizing that Government support may be essential in securing an early start on this project, recommended that the National Science Foundation indicate its willingness to consider making available up to $250,000, if required, for this purpose.

The report of the Subcommittee on Fundamental Geochemical Research proposed five projects. These are:

1) Study of low viscosity fluids in sediments and volcanic rocks.
2) Study of hydrothermal differentiation of igneous rocks.
3) Study of environment of ore deposition.
4) Isotopic studies bearing on ore deposition.
5) Study of intrusions with or without related ore deposits.

The report of the Subcommittee on Fundamental Geological Research listed recommendations in research in the following outline:

I. Ore-Forming Processes
   A) Metamorphic and metasomatic processes.
   B) Magmatic processes.
   C) Pegmatitic and hydrothermal processes.
   D) Sedimentary and diagenetic processes.
   E) Weathering and enrichment.
II. Environment of Ore Deposition
   A) Regional problems.
   B) Local problems.
III. Special Problems and Techniques
   A) Laboratory problems.
   B) Field problems.

It is interesting, but not surprising, to note that both preceding reports emphasized the need for fundamental research in ore genesis and ore deposition. If these were better understood, exploration not only by geologic methods but also by geophysical and geochemical prospecting methods would be greatly assisted.

The report of the Subcommittee on Fundamental Geophysical Research recommended three avenues of research which are quoted in part as follows:

Regional Studies. Regional maps of gravity, magnetic intensity, geothermal gradient, crustal thickness, radioactive background and other variables related to structure are of fundamental importance and should be prepared. Existing data should be compiled, but many new measurements are needed.

Basic Physical Research. The following kinds of studies are recommended: measurement of physical properties of rocks *in situ*; correlation of laboratory with field measurements of physical properties; attention to reproduction of field conditions in the laboratory; closer attention to the problem of sampling; measurements under wider ranges of conditions such as temperature and pressure; correlation of different sets of physical properties with each other and with chemical and mineralogical composition; investigation for new properties to measure; improvement of techniques for measuring physical properties; periodic revision of *The Handbook of Physical Constants* by Birch. Research should be conducted on physical processes acting in geological environments, such as flow and faulting of rocks, circulation of underground water, electrical and thermal conduction of rocks, and generation of natural potentials.

Methods of Exploration. It is expected that the fundamental research will form a basis of new and improved methods of exploration. However, it is felt that fundamental research is in greater need of support and will in the long run result in a better return than exclusive concentration on improvement of present techniques.

U. S. Geological Survey: Research by the Geophysics Section in the physical properties of earth materials is being done in two USGS Physical Properties Laboratories: at Denver, Colo., and at Silver Spring, Md. In general, the laboratory in Denver makes studies of those physical properties of interest in geophysical exploration problems, particularly those of the mining industry. The laboratory in Silver Spring is primarily concerned with studies of physical properties that relate to basic geologic processes and concepts. There is no sharp dividing line, however, between the functions of the two laboratories.

In Denver field and laboratory studies are made of electrical, thermal, and magnetic properties. Resistivity and dielectric constant are measured at frequencies of a few cycles to 50 megacycles in the laboratory. Logging devices for measuring dielectric constant and the electromagnetic properties (conductivity and magnetic susceptibility) have been developed and tested. An analog model, consisting of resistor and capacitor networks, for studying induced polarization effects over a layered earth was completed and tested. Equipment for measuring thermal conductivities of core samples has been completed for installation in the Denver Physical Properties Laboratory. Studies of physical properties on a regional and geologic basis are under way. These include uranium-bearing sediments from the Colorado Plateau, igneous and metamorphic rocks from the Colorado Rockies, copper-bearing rocks from Tucson, Ariz., and the iron formation in Minnesota.

In Silver Spring, studies are continuing of the remanent magnetization of rocks. A new research study of the strength and elasticity of rocks, and the thermodynamic properties of rocks, has been started. Measurement of dynamic elastic moduli, absorption and dispersion of elastic waves, rock deformation, and calorimetric properties are included in this new program.

A study of temperatures in drillholes in Alaska, on the Colorado Plateau, and in the Colorado Rockies is being made.

Analytical and model studies of magnetic and gravity fields were continued. Theoretical and experimental studies of the absorption and scattering of gamma radiation in relation to airborne radioactivity prospecting and drillhole logging are under way.

The physical behavior of radon in a geologic environment and in the laboratory is being studied. Faults and the influx of ground water into streams may be located on the basis of anomalous radon concentrations in ground and surface waters. Field and laboratory studies of the occurrence and distribution of uranium and thorium and their decay products in oil-bearing and gas-bearing rocks were continued.

Abstracts of geophysical literature from sources throughout the world were published in the 165th issue of *Geophysical Abstracts*. Compilation of physical properties for the interpretation of resistivity data is in progress.

Currently the **Geochemical Exploration Section** is studying the possible usefulness of isotopic studies. A. E. J. Engel has found appreciable differences in the oxygen isotope values in the quartz and carbonates in the great dolomite halos that are spatially and temporally related to ore in the Leadville limestone. These differences are fairly systematic with respect to ore and obvious conduits. To facilitate the application of these findings to practical prospecting, the Section is trying to develop a simplified field technique for measuring the isotope ratio in carbonate rocks.

Geological Survey of Canada: An aeromagnetic survey was completed this spring in an undisclosed area over a granite batholith having about 1000 ft of relief. This project was undertaken at the request of a group of geophysicists attending the **Society of Exploration Geophysicists** annual meeting in Denver in the fall of 1955. This group felt that a number of tests should be flown at a barometric altitude of 4000 to 10,000 ft over basement material outcropping on the surface and having considerable relief. The purpose of the surveys would be to see how successfully topographic relief of basement material can be interpreted from aeromagnetic results. One area has now been flown and compiled and the results will be sent to the Central Committee for distribution to those interested in trying to interpret the topography.

Geochemical work on the genesis of ores is continuing in the laboratories in Ottawa. This includes studies of lead-zinc-silver, uranium, gold, and copper deposits. In addition, detailed work is progressing on the isotope geology of sulfur in sulfide deposits and in petroleum and of lead in lead-silver and uranium deposits.

Research in Educational Institutions

Research in universities is done by students to accumulate thesis data. However, in some cases research projects are sponsored by industry or by government agencies and are conducted by special researchers. Also, there are instances where some universities that are government-sponsored act as government agencies in pursuing exploration operations and research. No attempt has been made to differentiate sponsorship.

The School of Mines of the **University of Alaska** reports that the Geochemical Research Laboratory, after theoretical analysis of the molecular structure and of the physical and chemical properties of the solvents, reagents, etc., developed reconnaissance geochemical prospecting methods using unleaded gasoline as solvent in the place of difficult to obtain and toxic solvents such as xylene, carbon tetrachloride, chloroform, and acetone. Chemically pure sodium chloride, sodium bicarbonate, and potassium citrate in solid form were used instead of specially prepared reagent solutions. Field work has been conducted in the Fairbanks and the McLearn River districts over known deposits of lead, copper, zinc, and silver where the methods were proved.

Research at the Institute of Geophysics of the **University of California** covers many phases of basic importance. These include rock deformation under high pressure, phase transitions in rock minerals under high pressures and temperatures, seismological model studies and associated studies in theoretical seismology, electromagnetic model and associated theoretical

studies, studies of natural fluctuations of the earth's magnetic field at the acoustic frequencies, gravity studies at sea and in the coastal areas, and gravity-tide studies relative to the yielding of the earth.

Thesis problems at the geophysics department of the **Colorado School of Mines** include two on wave generation and propagation, one on isostatic reduction of gravity stations in Colorado, one on a study of the negative separation of contact logs opposite shales, and one on a mineral exploration survey. To acquaint students with field operation and problems and to obtain data for interpretive study, seismic, gravity, and magnetic surveys were conducted on the structural investigation of the Front Range of the Rocky Mountains. The resistivity, self-potential, and electromagnetic methods were applied to a mineral exploration problem near Ouray, Colo., in cooperation with mining geology faculty and students.

The research program at the Lamont Geological Observatory of **Columbia University** is making important fundamental contributions in the fields of seismology, gravity, oceanography, geomagnetics, marine geology, marine biology, meteorology, and geochemistry. Of immediate interest to those concerned with exploration is the study and use of seismic models.

The division of geological sciences at **Harvard University** is involved in a broad program of research on physical properties of materials.

The department of geology and geophysics at **Massachusetts Institute of Technology** has the following sponsored research projects under way or in consideration: isotope variations and geologic age measurements, exploration seismic record interpretation, origin and significance of remanent magnetism in sedimentary rocks, electrical properties of rocks with exploration applications, and observational study of the equilibrium nature of metamorphic processes. There also are a number of research projects, mainly seismic, under way as theses material.

At the **Michigan College of Mining and Technology** depth to bedrock in northern Michigan was determined by the reflection seismic technique utilizing the High Resolution equipment of **Houston Technical Laboratory.** At present, graduate students are conducting induced polarization, electromagnetic, and gravity research.

A **University of Minnesota** graduate thesis presented a gravity survey of several tens of square miles in southwestern Minnesota outlining the boundary of the Sioux quartzite and estimating depth to bedrock. The former was interpretable, the latter only in a general way. An attempt is being made to miniaturize seismic refraction equipment for shallow exploration. This is being done by use of transistors and involves no recording and no explosives, except for depths greater than 50 to 100 ft. H. M. Mooney and W. W. Wetzel published *The Potentials About a Point Electrode and Apparent Resistivity Curves for a Two-, Three-, and Four-Layer Earth,* with a set of 2268 Master Resistivity Curves.

The **University of Oklahoma** announces that a paper, "Streaming Potential in Spherical-Grain Sands," by C. E. Bleil, will soon be published in the *Journal of the Electrochemical Society.* This paper describes basic information concerning electromotive forces generated when water flows through a sand or a capillary space.

At **Pennsylvania State University,** a mineral conservation section was created as a new section of the College of Mineral Industries to investigate the mineral resources of Pennsylvania and to perform basic and developmental research leading to new methods of discovery, extraction, and processing of minerals. The projects already under way in the department of geophysics and geochemistry include studies of typical sulfide deposits using the self-potential method and studies to evaluate the relative efficiency of resistivity and seismic surveys as a means of locating ground water in Pennsylvania. Two professors are currently engaged in completing a new mass spectrometer specially designed for studies of geologic age and of the isotope ratios of such elements as oxygen. It is hoped that this will provide an indicator of the conditions of formations of rocks and mineral deposits. In seismic research, the main progress has been further development of techniques developed at **Pennsylvania State University** of measuring the energy and frequency spectrum of seismic pulses. It is now possible to obtain a rapid determination of the frequency spectrum of any pulse recorded. In geochemistry a large part of the work continues to be phase equilibrium studies related to the origin of igneous and metamorphic rocks.

At the **University of Utah** studies of the electrical properties of synthetic metalliferous cores are in progress. In addition, graduate research includes variation of intensity of radio waves from commercial radio transmitter stations over geologic structures, radon studies of rocks, regional gravity surveys, seismic model studies, and interpretation procedures in various geophysical methods.

Washington University of St. Louis reports research in subsurface gravity observations. This investigation constitutes the material for a doctoral dissertation to be completed in June 1957. Four other students are in the process of carrying out applied geophysics problems.

At the **University of Wisconsin** work is in progress on regional geology, regional and world-wide gravity utilizing pendulums and gravimeters, the application of gravity to exploration for nonmagnetic iron ores, seismic surveys in the Great Lakes, and determination of crustal structure in Mexico. The latter was the subject material for a paper delivered by G. P. Woollard at the **International Geologic Congress** in Mexico City.

At this meeting, J. E. Riddell of **McGill University** stated that copper anomalies exist in lake-bottom sediments directly overlying known copper ore in the Chibougamau district, suggesting that metals can move and develop anomalies in the reducing environment prevailing beneath glacial lakes.

The geophysics staff of the department of physics of the **University of Toronto** is supervising graduate research in age determinations, gravity and seismic work, rock magnetism, and geomagnetism. For the purpose of obtaining information for the Glaciological Program of the International Geophysical Year, and also to train for additional work next season in the Arctic on Ellesmere Island, 11 men spent three months on the Salmon and Leduc Glaciers studying glaciers by geophysical methods. These glaciers were chosen because no glaciological work had been done in their vicinity and because access to the Granduc mineral deposit may have to be by tunnel under one or the other of these glaciers. Three hundred and fifty determinations of the thickness of the glaciers were made by seismic studies. Complete gravity surveys were made along 20 miles of glaciers, and an accurate survey of the area investigated was completed. Geophysicists from the **University of Toronto** have made gravity surveys of a large region in Ontario lying east of Georgian Bay, while American geophysicists have surveyed the region to the west of Lake Huron. With a view to partially filling the gap caused by Lake Huron, gravity surveys were made by sending small boats to all the more remote islands in Georgian Bay.

In the physics department of the **University of Western Ontario** research and investigations are being done in electromagnetic modeling, geological interpretation of aeromagnetic maps, application of geophysical techniques to the study of the ground-water resources of southwestern Ontario, thermal conductivity of rocks and soils, gamma-ray attenuation in rocks and soils, radiometric assaying of ores, radioactive age determinations, and application of solid-state theory to the problems of the earth's interior. At the annual meeting of the AIME in New York in February 1956, R. J. Uffen delivered a paper, "Multiple Scattering of Gamma Rays from a Buried Point Source," by R. J. Uffen and W. B. Muir.

It was demonstrated at the International Geologic Congress that the **Royal School of Mines,** of London, has been active in geochemical research. A simple and sensitive test for tin in soils and rocks was announced by G. A. Wood. In addition, a number of new chemical tests for uranium were described. John Webb, in summarizing recent geochemical activities in Africa, reported that analyses of residual, lateritic soils in the Rhodesian copper belt had become one of the most widely used methods of both reconnaissance and detailed exploration, one company handling samples at the rate of over 100,000 per year. Under most circumstances, readily soluble copper as determined by Holman's rapid test (dithizone dissolved in petroleum spirits) gives patterns at least as good as total copper determined after extraction with hot acid. He also reported that tests of soils for cobalt, chromium, zinc, nickel, or base exchange capacity were being used effectively for location and delineation of diamond-bearing kimberlite deposits.

The Institute of Applied Geophysics of the **University of Munich** has conducted seismic, magnetic, and radioactive research and has been making density determinations. The seismic research has consisted of measuring the thickness of the Great Gurgler Ferner glacier in the East Alps by the refraction method; a practical method has been found of determining Young's modulus by observing longitudinal and transverse velocities in rocks; the thicknesses of unconsolidated formations in the Alps and in the river areas of the Upper Pfalz were determined; in two Bavarian areas the shocks suffered by buildings and constructions resulting from explosions set off during road construction were observed; in the laboratory, a model was constructed to study the propagation of elastic waves; and a paper was completed by O. Foertsch discussing the problem of absorption of elastic waves. The magnetic and radioactive investigations were made for geologic correlation problems. Exact density determinations on underground rock samples of Molasse in the Front Alp area were made. Densities are altered by the tectonic stresses on the rocks.

A. Belluigi has transferred from Cagliari in Sardinia to the **University of Perugia,** where he has founded the Instituto di Fisica Terrestre. Improvements of new equipment, *Mind, Bicaram,* etc., have been made at the Institute for their re-employment in the field in mineral exploration during 1957. With the hope of perfecting a direct method for oil prospecting, the Elflex method is being re-examined. Preliminary studies indicate that present difficulties with the method lie in interpretation of results. Fundamental papers published during the year in *Zeitschrift fur Geophysik, Gerlands Beitrage zur Geophysik, Annali di Geofisica,* and *Geofisica Pura e Applicata* have a definite bearing on the problem.

Because of the national importance of finding potable ground water, Vacquier's induced polarization technique is being thoroughly investigated. It is felt that a complete theory of gaps-potential will resolve both the interpretative problems of Elflex and induced polarization and that with theoretical and experimental studies the method has a certainty of success.

While at the department of geology and geophysics at **Sydney University,** Australia, V. Bhaskara Rao improved an existing technique of obtaining magnetic hysteresis curves of rock samples by introducing a C-R integrating circuit to integrate the output voltage, which is proportional to dI/dt, thus obtaining the value of intensity of magnetization directly on the screen of the Cathode-ray Oscillograph. Two papers were published: Bruckshaw and Rao, *Proceedings of Physical Society,* vol. 163, p. 931, 1950; and V. B. Rao, *Geophysics,* vol. XXI, no. 4, October 1956. Mr. Rao is now a lecturer in the geophysics department at **Andhra University.**

At the department of geophysics, **Andhra University,** Waltair, Andhra State, India, research is being conducted in magnetic, electrical, and ultrasonic properties of rocks. Investigations are being made on the Lower Gondwana coal fields of the Godavary Valley in the State.

Geophysics — Education

To the credit of the universities, the consensus of opinion is that geophysics training is good. The only complaint is that there are not enough men being trained in this field. While most graduates are employed by the petroleum industry, there is a marked increase in student and faculty interest in the application of geophysics to mining. This, of course, reflects the conspicuous increase in mining geophysical activities.

In general, schools reported smaller graduating classes in 1956 than in 1955, and considerably smaller than anticipated in 1957. The trend seems to be increasing interest in the broad field of geophysics. The **Society of Exploration Geophysicists** has been very active in presenting talks and making information available to university and high school groups concerning geophysics as a career. Several companies are employing high school science teachers during summer vacations. The **University of Toronto** has recently held a conference on geophysics education. Other universities, government departments, and some of the largest mining and oil companies in Canada were represented. The University of Toronto hopes, with the help of industry, to start a summer school with scholarships for high school seniors and teachers and for freshmen entering earth sciences.

Several universities report new or revised geophysics curricula. The **University of Alaska** is giving noncredit courses in geochemical prospecting at a number of cities in Alaska for the benefit of prospectors. Harold Bloom has joined the faculty of the **Colorado School of Mines,** giving courses in geochemistry. The **Michigan College of Mining and Technology** is revising its curricula. This will lead to B.S. and M.S. degrees in geophysical engineering. At **Pennsylvania State University,** two new professors, R. N. Clayton and L. F. Herzog, have joined the faculty. **Texas A. & M. College** is offering a geophysics curriculum for the first time, leading to B.S., M.S., and Ph.D. degrees. The faculty consists of Paul Weaver and Peter Dehlinger. The geophysics faculty of the **University of Toronto** has been increased to six professors and lecturers. At the **University of Western Ontario,** a four-year honors course was initiated leading to a B.S. degree. Increased laboratory facilities are planned. **Andhra University, India,** now offers a three-year post graduate M.S.C. degree in applied geophysics. The curriculum has been expanded in geodesy, terrestrial magnetism, geochemistry, volcanology, tectonophysics, seismology, and ground water geology.

Acknowledgments

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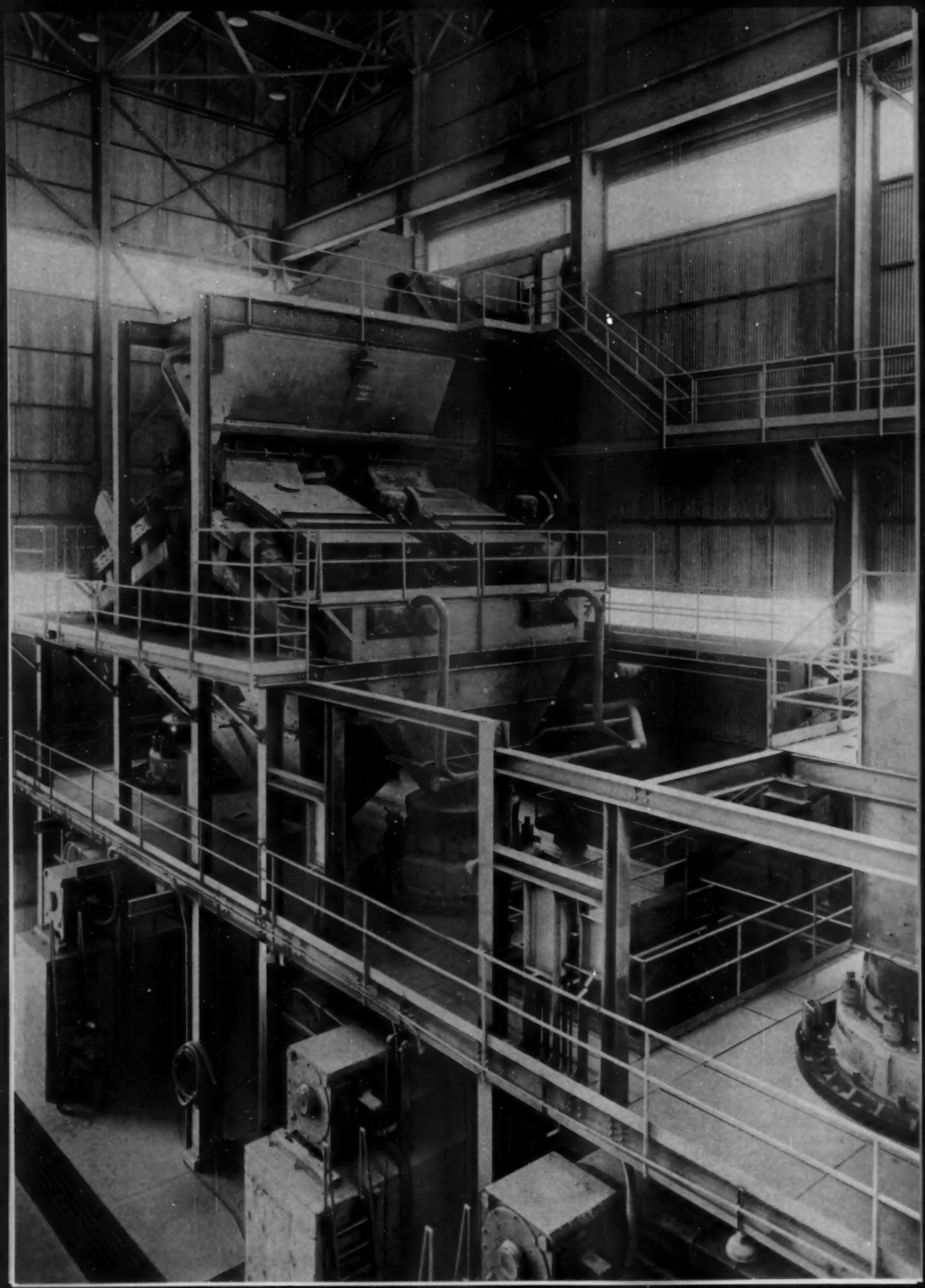


Annual Review

Beneficiation in 1956

by Norman Weiss

IF we were to measure progress this year in terms of large new mills and discoveries of fundamental significance we should certainly be disappointed. Outside of the uranium field there was little of a spectacular nature. San Manuel and Reserve completed their first year of operation; Erie approached readiness; the Toquepala project in southern Peru broke ground and gained speed. Important mill enlargements occurred at Inspiration, Anaconda, Ray, and Climax Molybdenum. A 3000-ton copper concentrator was completed at Pima, near Tucson. The Republic Mill of Marquette Iron Mining Co. started up in April. Abroad, the great developments in the African Copper Belt can be likened to the rapid growth of the porphyry coppers in this country.

Fundamental research was confined nearly entirely to iron ore flotation and recovery of metal values from leach solutions, particularly uranium. The large number of review articles this year reflected a desire to take stock and consolidate past gains before taking the next bold steps. Undoubtedly a shortage of competent young engineers and technicians is stunting the natural growth of theoretical investigation in the field of minerals beneficiation, as well as the conversion of ideas into action. We find our small stock of talented young scientists concentrated in a few centers of erudition because there are not enough to diffuse through the industry. It is safe to say that among mine administrators and managers there is more interest in the education, training, and welfare of the young engineer than ever before.

In September 1957 the fourth International Mineral Dressing Congress will take place in Stockholm. European progress in this technology has donned seven league boots these last few years, and it behooves us to keep up-to-date by observation and by means of translations of foreign technical papers.

Materials Handling

In *E&MJ* for June, A. W. Asman voices a plea for more precise design of belt conveyors, and describes several procedures for determining the factors needed for such design. Fire resistant belt construction is described by J. L. Thornton in *Mining Congress Journal*, September. Polyvinyl chloride belts, while possessing desirable fire and abrasion resistance, cost more than neoprene or rubber and require higher operating tensions.

The use of the high speed camera to help in the redesign of belt conveyor transfer points was described and illustrated by D. J. Reed at the AIME Annual Meeting, New York, February 1956. Best results in transferring to a 580-fpm belt occurred when the buffer belt ran 20 pct slower and discharged about 8 ft above the belt to a sloping transfer chute.

At the American Mining Congress meeting in Los Angeles M. A. Stokke described the new conveying and electronic weighing system in use at **Anaconda**. Pneumatic belt scales are being given a thorough trial at Anaconda. Air in excess of 20 psi is reduced to constant pressure, then used to balance the load on a small weighing head by means of a diaphragmed weight chamber and bleed nozzle. The pneumatic scale is claimed to be accurate and has the advantage of requiring no structure over the belt.

Handling of bulk solids out of bins is a constant problem. The fine ore bin of the new **San Manuel** concentrator represents an advance in design. The bin is 45 ft wide, 55 ft high, and 860 ft long with live load capacity of 45,000 tons. Feeder belts at 22-ft intervals, normal to the long axis of the bin, draw ore from 32 slots each 27 ft long. Because the slot width and its height above the feeder increase constantly in the direction of feeder travel the contents of the bin drops uniformly. Each of the eight rod mills is fed from four of these feeders, two of which are variable speed, weigher controlled.

Recent improvement in the carcass of a conveyor belt has resulted in a disproportion between carcass and cover, and now there is need to restore the balance. High tension construction is not a good investment if the cover goes long before the carcass life has been expended. A substantial amount of cover wear takes place on the return run, so there is new interest in the turn-over belt installation in which the belt is actually turned so that the dirty top cover does not contact the idler faces on the return run.

The use of hydrocyclones to build tailing dam embankments is growing in this country. First used on a large scale by Roan Antelope, cyclones were subsequently used at Silver Bell to overcome high viscosity caused by clay. Without the cyclones it was impossible to obtain a sand-slime separation for bank building. The procedure will be described at the AIME Annual Meeting in New Orleans by R. Salter. A similar procedure was adopted temporarily by Copper Cities, and San Manuel also builds its embankment by cyclones. Magma Copper is considering cyclone use in the new disposal area and tests are being made at Chino.

At the New Orleans meeting R. W. Jigins will describe the Braden system of tailing disposal. P. F. Allen described Morenci's disposal system in MINING ENGINEERING, July. This method, by which the pipe line is supported on the downstream bank instead of on trestles, has been advantageously adopted at Climax, as well as at the newer dams in the Southwest.

Corrosion in uranium plants was discussed by H. C. Peterson at Colorado MBD Subsection's annual meeting at Colorado Springs in May. The use of plastic linings and tubing, rubber hose, and wood tanks answered most needs.

Crushing and Screening

The coarse and fine crushing plants of the **Reserve Mining Co.** at Babbitt and Silver Bay, Minn., completed their first year of operation. The crushing operation, largest of its kind in the world, was briefly described in *Mining World*, October. The design of the coarse crushing plant continues the modern tendency in taconite crushing, namely, to reduce the number of re-handlings of this very hard, abrasive material. A 60-in. gyratory with grizzly needs about 100 ft from dump rail to bottom. Add another 70 ft and the secondary gyratories can be fed directly from the primary, without conveyors or feeders. At Babbitt the four 30-in. gyratories are thus installed, and these may be hoisted topside for repair.

Wear caused by the silicious taconite is extreme, and the mantles and concaves of the big primary crusher last less than 1.5 million tons, about 4 to 5 weeks, and require two or more shifts for replacement. The idea of installing 60-in. gyratory crushers in duplicate, one as a spare, is given more than passing consideration by some taconite operators.

The coarse crushing plant of the Erie taconite concentrator near Aurora is similar to Reserve's in design.

Fine crushing to 1 in. is accomplished at Reserve in eight 7-ft short head cone crushers, arranged in four lines of two crushers in series, each crusher preceded with a screen.

San Manuel's crushing is unique in that the ore, which is produced by block caving, comes directly from the mine to 7-ft standard cone crushers. These, however, are equipped with heads and bowls that give a 17½ in. wide feed opening.

The new **Hardinge** Disc Roll mill is an adaptation of the Loesche mill, developed originally in Europe. Similar in action to the old Chilean mill, it is particularly suited for fine crushing of soft materials like limestone, coal, bauxite, clays, and raw cement mix, at rates up to 50 tph. Grinding is accomplished by means of two rolls riding on a rotating horizontal table. Feed is deposited on the center and the table revolves at approximately the critical speed of material retention at its periphery. The mill is air-swept. At the **Summit Mining Co.** at Aspers, Pa., a disc roll mill is grinding sericite to over 95 pct −200 mesh.

The **Aerofall** mill found new applicaton on uranium ores on the Colorado Plateau. Other plants now under construction will also use this mill. At Messina in Africa and at Coldstream in Canada, Aerofalls will take run-of-mine size sulfide and produce flotation feed. At Messina the product is expected to run 85 pct −200 mesh. L. A. Waspe of Johannesburg, writing in *Mining World*, May, related the experience with Aerofall mills at East Daggafontein and other African mines. The big mills accomplished selective grinding, causing liberation of the heavier mineral constituents with little slimming, while at the same time avoiding undue formation of gangue slime. Increased extractions in leaching processes were found on ores of gold or uranium. Filtering rates improved 25 pct over conventional grinding. Lower reagent consumption (cyanide or acid) also resulted.

The following notes from **Germany** are of interest because that country is making substantial progress in the design of milling equipment.

Following the U. S. trend, some German jaw crusher manufacturers are giving up heavy castings in favor of welded steel construction. Fluid drives are commonly applied. Two motors are used for the largest machines, one of these only for starting. A crusher can be re-started even after stopping with full load.

Wedag's cone crusher employs axial and radial ball bearings to save power and headroom. Vertical and horizontal movement of the bowl is controlled by hydraulic cylinders, set to permit passage of tramp metal.

The **Krupp** firm offers a new crusher that combines certain features of the jaw and the cone crusher. A vertical section of its crushing zone very closely resembles a half-section through a Symons crusher. High capacity and low fines production is claimed for it. A 32x50-in. machine is now being used in a Scandinavian iron mine, and a larger size is under development.

Krupp resonance screens are being used widely in Germany, Austria, and Sweden. It is claimed that their slightly higher price is balanced by very low headroom, the setting being almost horizontal. Power consumption is about the same as on our vibrating screens, but a smaller motor does the job because less torque is required for starting.

At the AIME annual meeting in New Orleans N. Kuenhold will discuss the factors that govern the selection of a vibrating screen.

Grinding and Classification

The past year has been fruitful in two principal directions: rod milling and liquid-solid cyclones. Valuable operating information is being accumulated on rod milling by virtue of the recent installations at Chuquicamata, San Manuel, and Reserve, and expansion at Anaconda. Additional data will no doubt be available in time at Erie, Pilotac, Utah Copper, White Pine, Pima, and others.

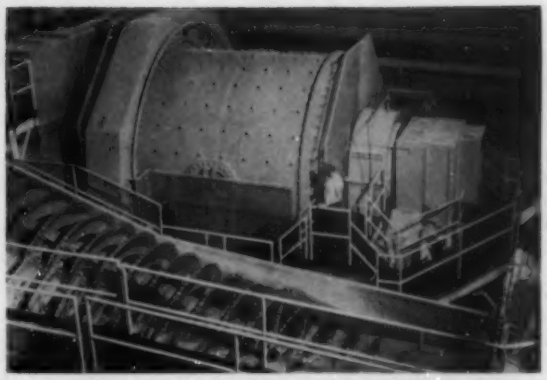
ROD MILLS: A number of factors in rod mill grinding are in a healthy state of controversy: length-to-diameter ratio, high versus low pulp level, speed, scoop versus spout feeding, feed size, pulp density. At the 1957 AIME Annual Meeting A. S. Henderson and E. M. Furness will describe Reserve's experience with rod mills in grinding magnetic taconite. A major part of this investigation took place at the Babbitt milling plant where a 10½x12-ft rod mill was later lengthened to 14 ft 7 in. and led to the purchase of 10½x16 ft rod mills for the E. W. Davis plant at Silver Bay. A similar investigation is continuing at Oliver's Pilotac mill near Virginia, Minn.

Rod mills 10-ft diam, and larger, are relatively new, and perhaps a lot of the recent difficulties with rod ejection, rod breakage, and *jack-strawing* result from the fact that the diameter was increased without retaining the 1.4 to 1.6 length-to-diameter ratio of the earlier rod mills. Some operators feel that proper introduction of the feed into the rod charge is also a major requisite of trouble-free operation and the diameter of the discharge opening is likewise important. In a questionnaire recently mailed to a number of rod mill operators John F. Myers, whose work in the grinding field is known to all, asks for their opinion of the best ratio of mill diameter to discharge opening to produce highest capacity and efficiency with a minimum of tramp oversize. Excessively large discharge openings, Mr. Myers says, are notoriously inefficient and low in capacity but usually their product is fairly free of tramp oversize. On the other hand, very small openings are generally offenders in developing tramp oversize, but are of high capacity and efficiency.

A comparison of wet vs dry grinding was offered by Fred Bond at the Mining Congress meeting in Los Angeles. Between these two is a range of water content that forms a thick mud unable to flow through the mill. Closed circuiting of dry mills requires much more power than wet, but metal wear in dry mills is lower. Comparative costs in a hypothetical case of a silicious ore were 38.6¢ per ton for wet grinding and 34.7¢ for dry.

The performance of shell liners in ball mills at **Climax** was set forth by Frank J. Windolph in MINING ENGINEERING, August. Comparative data were presented for shiplap vs single wave, reverse shiplap vs shiplap, thin shiplap vs double wave, shiplap vs spiral, effect of mill speed, and effect of liner thickness upon capacity. Thick shiplap liners gave the lowest liner cost per ton, but thin shiplap gave the highest capacity. A later test with an almost smooth liner at 86 pct of critical speed gave 6 pct more capacity but 40 pct greater liner cost than the regular liners.

Climax started the first of their two new 13-ft diam (inside shell) by 12-ft ball mills this year and will place the second in operation about March 1957. These are driven by 1000-hp motors and operate at 65 pct of critical speed. The first mill drew 1060-hp after three months operation. These large low-speed overflow mills are expected to show substantial savings in operating costs as compared with the high speed grate mills used in the rest of the mill.



New 13 ft diam x 12 ft ball mill circuit is at Climax mill in Colorado. A second unit of this same size will be placed in operation in 1957.

Kennecott's Utah Copper Div. has purchased a 10x16-ft rod mill for testing in parallel with their conventional grinding sections that employ 44-in. crushing rolls and 7-ft ball mills. The mill has a special removable 2-ft shell section and a sliding pedestal base that will permit operation with a 14-ft length, as well as the nominal 16-ft length. The purpose of this is to find out the effect of mill length on tramp oversize in the mill discharge, the effect of mill length on product size in the upper end of the screen scale, as well as in the −100 mesh fraction, and to figure whether there is any power economy or penalty in grinding in this extra mill length. The mill will have a 1000-hp motor and a variety of pinion gears to determine the influence of mill speed on its grinding job. No doubt the test program will take some time to produce worthwhile information, since so many variables are to be tested.

Several papers on grinding practice and theory will be presented at the coming AIME Annual Meeting in New Orleans. F. M. Lewis and J. E. Goodman will describe the capacity increase at **Tennessee Copper's** Isabella mill, and add support to their belief in low ball charge and "in-mill" classification. F. C. Bond will present a paper on the Third Theory of Comminution, in which particle exposure time will be evaluated.

Autogenous grinding pebble mills following conventional rod mills have been recently applied on uranium ores in Canada to reduce contamination by iron, which is detrimental in the acid leach. **North Rankin Nickel Mines** will also use screened ore for grinding at their new 250-tpd copper-nickel mill at Rankin Inlet.

From Germany comes word of recent tests by **Klockner-Humboldt-Deutz** on ball mills running on rollers. Thrust, which is the chief problem in trunnionless mills, is taken care of by the design of the tires and rollers, preventing any tendency for the mill to drift laterally. Advantages claimed are easy access to feed and discharge points, ease of adding balls and rods, and minimum weight of cast steel parts. One of these mills, an 8x8-ft equipped with variable speed drive, has been under continuous test for two years. The new Stolberger zinc concentrator will employ these roller drive mills.

Research work on the grinding of ore particles while exposed to various gas-forming compounds is being carried on in Germany. Interesting variations in grinding response are noted in the presence of such compounds as acetone, carbon tetrachloride, benzol, and hexane.

CYCLONES: In the field of classification the liquid-solid cyclone stole the show in 1956. Although its acceptance in the U. S. as a closed-circuit classifier on ore has been reluctant because of high maintenance costs, use on intermediate products such as magnetic iron concentrate or lead, copper, and zinc middlings or rougher concentrates has become conventional. The ability of the cyclone to make sharp size separations and to produce selective classification of mineral particles with respect to gangue is finding new application each day. Its value as a process tool is suggested at each turn in the flow sheet.

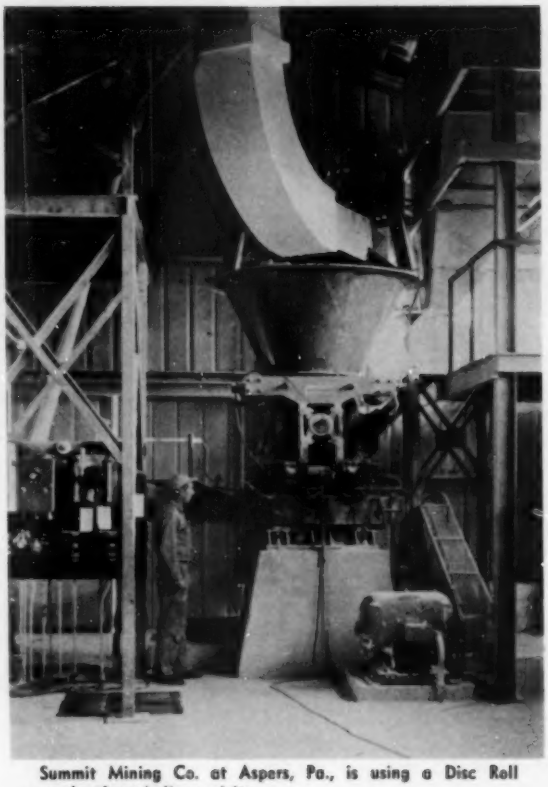
During 1956 scores of base metal operations started or intensified their studies of cyclones for classification in the main grinding circuit. Control of density and selectivity of grind prove to mean far more with one ore than they may to another. In numerous cases where persistent or periodic softer ore has been encountered, output has increased up to 10 to 20 pct by holding a good circulating load with the requisite grind. Careful attention to cyclone design features has proven that very low pressures are needed to meet the desired specifications of sizings and densities in most plants. Wear on cyclones has been close to nil and in holding pump speeds low by tight closures and low dynamic head to the cyclones one finds an important key to the cyclone economics.

In a paper presented at the 1956 AIME meeting in New York R. Krebs stated that a circuit with both a classifier and a cyclone is a logical flow sheet for most single-stage grinding. This is exemplified at Silver Bell and Morenci, where cyclones are supplementing spiral classifiers in test sections. With two-stage grinding the application of the cyclone is even more attractive, Chino and Anaconda being examples.

At the American Mining Congress meeting in Los Angeles, P. A. Lemke presented a paper on experience at **Chino** where cyclones do many jobs. Applications include: 1) ahead of concentrate thickeners to handle overloads and to aid filtration; 2) classification of flotation middling products and return of the underflows to regrind; 3) classification in a concentrate regrind; 4) desanding milk of lime; and 5) cyclones in the main grinding circuit on the second stage of grinding. The first four of these applications have been widely adopted by numerous plants as also has the use of cyclones for making embankment for tailing dams.

Silver Bell employs cyclones in various parts of its operation at flows ranging from a low of 12 gpm to a high of 1500 gpm. Cyclones have been employed in the regrind section of the concentrator since the start of operations. Many small improvements in the method of operation have been found, of which perhaps the most notable is the recycling of part of the DorrClone overflow back to the pump that feeds the cyclones in order to maintain constant pressure and volume.

At the present time the Silver Bell Unit is conducting a cyclone test on the primary ball mill circuit in an effort to reduce the +65 mesh tonnage that is produced by ordinary classification and also



Summit Mining Co. at Aspers, Pa., is using a Disc Roll crusher for grinding sericite.

to raise the pulp density of the flotation feed and thereby achieve longer flotation time.

Three 20-in. Krebs cyclones served by a manifold and Linatex 10x10-in. pump working at approximately 3.5 psi pressure are used. The primary classifier overflow at 55 to 60 pct solids is sent to the cyclones and only the very coarse oversize is returned by the classifier rakes to the ball mill scoop box. The cyclone overflow is maintained at approximately 28 to 30 pct solids as compared to 23 pct on the normal classifier overflow, depending on the relative grind and tonnage. Differential classification of the heavier minerals is realized. There are indications that copper recovery benefits by the finer grind and increased flotation time which are possible with the cyclone installation.

Morenci's experience with cyclones in primary and regrind circuits was described by J. E. Papin and R. C. Barr in *Mining Congress Journal*, August. Experimentation is continuing. Cyclone classification at **Manganese Inc.** was described by S. J. McCarroll in *Mining Congress Journal*, July. At the Northeastern Mining Branch meeting at Hershey, Pa., D. D. Melin spoke on the function of liquid-solid cyclones.

At the coming AIME Annual Meeting in New Orleans E. C. Herkenhoff will attempt to classify the field of cyclone application and present average data of practical value. Stephen E. Erickson will summarize the development of the hydrocyclone. T. M. Morris will present cyclone operating data compiled from a number of plants. F. D. DeVaney will discuss the application of cyclones in the closed-circuit grinding of magnetic taconites, placing emphasis on the problems inherent in handling fine magnetite in pool-type classifiers.

Concentration

The Copper Cities mill of **Miami Copper Co.** will install mechanical flotation machines in a test section for comparison with its air cells in primary rougher flotation. A small pilot plant is being installed to test the feasibility of molybdenite production from the copper concentrate. Automatic pH control has worked out so successfully in one section of the mill that it is to be extended to the whole mill.

FLOTATION: The leach-precipitation-float treatment of Kennecott's Ray ore will be described at the AIME meeting in New Orleans by A. W. Last, L. Eaton, and J. L. Stevens. This important modification of the **Hayden** concentrator, scheduled for tuneup late in 1956, followed laboratory and continuous pilot-scale testing. It includes facilities for leaching, desliming, precipitation, and flotation, also a contact sulfuric acid plant and a sponge iron plant, both utilizing pyrite recovered from the ore. The flow sheet makes a sand-slime separation for acid treatment of the fines containing oxidized copper. The dissolved copper precipitates on sponge iron and is floated.

Also at Hayden, Kennecott will soon start construction of a new crushing plant and a major mill extension, all designed to increase capacity 50 pct.

At the New Orleans Annual Meeting H. K. Martin will describe the new Phelps Dodge Lavender Pit concentrator at Bisbee, Ariz.

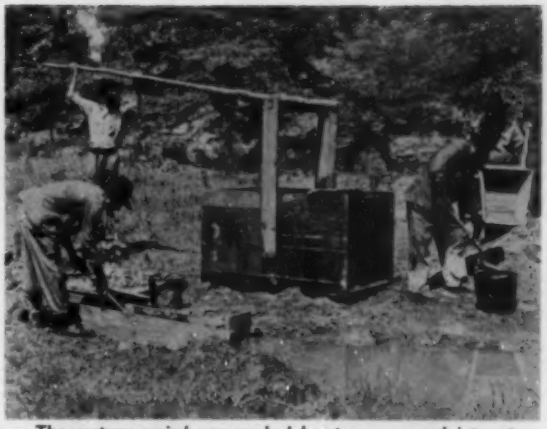
Silver Bell added a flotation section to recover molybdenite from the copper concentrate, employing the ferrocyanide process developed at Morenci. The copper concentrate is first conditioned with sulfuric acid and sodium ferrocyanide, then refloated. The rougher concentrate is thickened, cleaned three times, then reground and cleaned six times more. The final molybdenite concentrate is dried in a screw conveyor by infra-red Globar elements. Automatic control of pH and pulp density are essential features.

Consolidation of **Tennessee Copper Co.'s** milling operations in one plant, at London, Tenn., will be completed early in 1958. All pneumatic flotation machines will be replaced by mechanical cells.

A well-equipped pilot plant of 60 tons daily capacity has been placed in operation at **Cerro de Pasco** for the purpose of working out the flotation treatment of their lead-zinc ore reserves, much of which runs high in clay and soluble salts. An interesting application of liquid-solid cyclones was recently made at the Paragsha concentrator of Cerro de Pasco. A 24-in. cyclone makes a 325-mesh separation on 1000 tpd of flotation tailing, and the underflow at 75 to 80 pct solids is reground to yield further metal recovery.

At the Sullivan concentrator of **Consolidated Mining & Smelting Co.** at Kimberley, B. C., a 100-ton pilot mill is being constructed within the main mill building to bridge the gap between laboratory testing and mill performance. The little plant will be kept in continuous operation and will test new reagent combinations and flow sheets that look promising in laboratory tests.

The first commercial flotation plant for the concentration of iron ores on the Mesabi Range is being built by **Jones & Laughlin Steel Corp.** to handle Hill-Annex tailing fines. It will employ sulfonate flotation. Pilot plant work on sulfonate flotation has been carried on by the Ozark Ore Co. of **M. A. Hanna.**



The postwar period was marked by strong renewed interest in gravity concentration, with new devices making a sharp contrast with this old scene.

New Jersey Zinc's new 1000-tpd zinc flotation mill at Jefferson City, Tenn., went into operation, and a second mill of 2000-tpd capacity is scheduled to start the middle of 1957 at Flat Gap, near Jefferson City. Twenty-five miles north at Timberville, Va., **Tri-State Zinc Co.** is building a 700-ton zinc flotation concentrator. **American Zinc Co.** is considering a new mill about 25 miles northeast of Mascot.

The *boiling* procedure for fluorspar flotation, long practiced in Colorado, has been successfully introduced in the Rosiclaire district of Illinois. The **Calvert City Chemical Co.** has placed in operation the first plant on the Kentucky side to employ flotation for lead, zinc, and fluorspar concentration.

Concentrating tables at the Phosmico plant of **Virginia-Carolina Chemical Corp.** have been equipped with aluminum decks to handle the +35 mesh fraction.

MAGNETIC & ELECTROSTATIC PROCESSES: One of the world's major sources of columbium and tantalum is at Jos and Odegi, Nigeria, where an alluvial deposit has been mined and concentrated by hand, the crude concentrate being upgraded and then separated by magnetic and electrostatic machines. Now **Kennecott** is converting the operation to mechanical mining, with a plant going up to pump the ore into a wet gravity separating mill that uses scrubbers, screens, cyclones, classifiers and tabling. This concentrate will be further upgraded in a rebuilt and expanded dry mill.

A number of interesting papers on the concentration of nonmetallic ores will be read at the coming AIME Annual Meeting in New Orleans. C. L. Sollenberger and R. B. Greenwalt will discuss the relative effectiveness of sodium silicates with various soda-to-silica ratios as gangue depressants in nonmetallic flotation. J. Hill Carpenter and R. F. Griffith will describe the concentration processes generally employed in the production of monazite from beach or stream type deposits. For these sandy ores the combination of gravimetric, high tension, and magnetic separations are standard practice. The application of electrostatics to the beneficiation of feldspar, potash, and pebble phosphate will be discussed by J. E. Lawver, E. Northcott, I. M. LeBaron, and W. C. Knopf. J. E. Lawver also contributes a paper on electrification measurements applicable to the electrical concentration of minerals on an industrial scale.

U. S. Bureau of Mines published RI 5213 on the effect of temperature on the electrostatic separation of minerals. This work by Foster Fraas shows that electrical conductivity of minerals increases with temperature, some changes in resistivity being irreversible, and includes valuable separation data.

The new **Wemco-Remer** dual-stroke jig was demonstrated at the American Mining Congress exhibits at Los Angeles. Dual eccentrics impose strokes of different amplitude and frequency, thus reducing dead spots on the bed and increasing permeability. The new jig has been applied in the concentration of iron, barite, fluorspar, and other ores, working in the size range below that of the heavy media separators.

Heavy media separation in Germany: A new ferris wheel separator made by Wedag is finding favor. The wheel consists of a ring of buckets rotating about a horizontal axis in the separatory vessel. The float product is impelled towards the discharge by a current imparted by the wheel, and the sink is elevated by the buckets. The feed and the two products are on one side of the machine, so two opposing wheels may be mounted on the same shaft. For high specific gravities (up to 3.55) spherical ferrosilicon can be used without impairing efficiency through excessive viscosity. These wheels are used successfully on siderite at several mines in the Siegerland, for red iron ores at the Fortuna mine, and for dolomite-magnesite ore in Radentheim, Austria.

Also in West Germany: Two new magnetic separators have been developed for fine separations. For low magnetic iron ore in the Salzgitter mines a high current separator upgrades fine-grained ores of hematite, limonite, and manganese minerals, proving its adaptability to fine particles by handling a limonite dust running 70 pct finer than 30 microns.

Krupp has taken over the Laurila (Finland) permanent magnet separator for fines. The Laurila separator consists of a rotating drum in which the magnetic system rotates at a different speed, causing continuous intermovement of the mineral particles.

Noteworthy is the application of dithiocarbamate collectors for lead ore flotation at the large Mechernich concentrator in the Eifel district of West Germany. This ore contains an unusually high percentage of cerussite. Xanthate, formerly used, has been replaced with Na-cyclohexyl dithiocarbamate. The superiority claimed for this reagent lies in the combination of a trivalent nitrogen and bivalent sulfur in one molecule. Similarly, in the U. S., this is a characteristic of Z-200, Dow's new copper and zinc collector, and of the well-known thiocarbanalid.

From Sweden: The Stripa method of heavy media separation of iron ores uses a floating bed of rather coarse magnetite concentrate in a shaking trough; it is being rapidly adopted for separating high grade lump ore at 3.5 sp gr. Among the new installations are Norberg and Bastkarn.

Extensive research in laboratory and pilot plant is going forward on the flotation of iron ores using tall-oil emulsions. Several plants now in construction will use this process. At Domnarvet magnetic oxide conversion is being investigated for utilization of low grade hematite ores.

A new dry magnetic concentrator, the Mortsell, employs centrifugal force to separate mixed grains. It is claimed to make coarser and cleaner concentrates than wet magnets.

The new large iron ore treatment plants at Kiruna and Malmberget went into operation this year for concentration of coarse magnetic iron ore.

Reserve Mining Co.'s taconite processing project, showing car dumper building in upper center, fine crushing building just below, and the quarter-mile-long concentrator building. To the left, steam marks the pelletizing building. In the foreground an ore carrier is moving into loading position. To the right is the new 50,000-kw power plant. The new community of Silver Bay is in the foreground.

Thickening and Filtering

The employment of synthetic flocculants as aids to settling and filtering is widening, and the nature of uranium recovery processes is perhaps affected as much by these flocculants as any other single factor. At the annual AIME meeting in New Orleans M. F. McCarty and R. S. Olson will present another paper on **Dow's** Separan 2610 and its value to mining operations. Classic thickening and filtering testing methods lead to erroneous conclusions, and modifications in these procedures are now desirable.

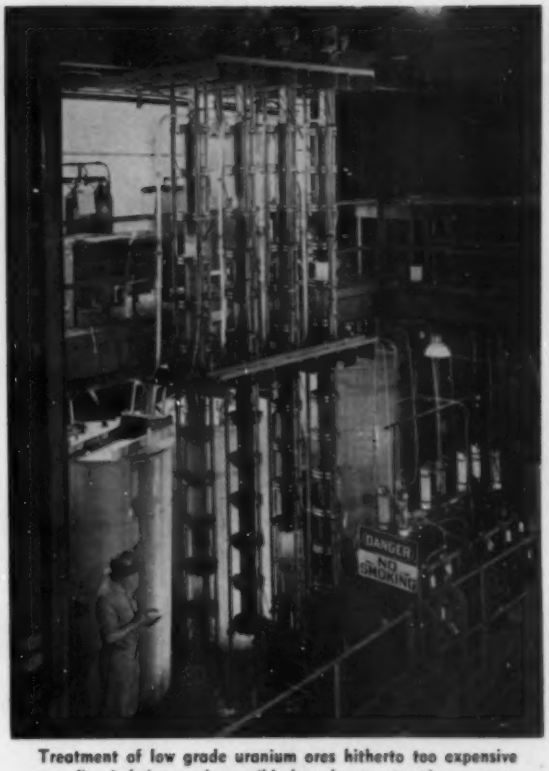
At the Copper Cities concentrator of **Miami Copper Co.** clayey material in the ore occasionally caused slime to accumulate in the 225-ft tailing thickeners, resulting in loss of water or loss of tonnage. The intermittent use of Separan, when needed, is very effective when used at the rate of approximately 0.003 lb per ton of ore.

Hydrocyclones are being used successfully on thickener feed pulp, not only to protect the thickener mechanically by removing the heavier and larger particles, but also, in many instances, by favorably modifying the colloidal and suspensoid nature of the fine feed.

Hydrocyclones are applied similarly to filtration, particularly the filtration of base metal flotation concentrates and taconites. The pulp to be dewatered is first classified in a hydrocyclone, the underflow going directly to the filter; then the cyclone overflow is thickened and filtered. This procedure will usually reduce the moisture content of the filter cake, and has the added advantage of reducing the sensitivity of the system by confining the thickening to only a part of the pulp.

The newest thing in filtration is **Eimco's** Rotobelt filter, which will be described at the AIME Annual Meeting in New Orleans by C. F. Cornell, R. C. Emmett, and D. A. Dahlstrom. A continuous vacuum filter of the drum type, the Rotobelt overcomes some of the disadvantages of the conventional drum filters by continuously removing and returning the non-blinding metallic or cloth media. Discharge is complete and cloth cleaning is continuous, so higher filtering rates, better washing, and lower moistures are to be expected.

In uranium milling the roller discharge for drum filters helps to handle sticky cake such as yellow cake precipitate. To reduce blowback on washing filters an air purge reduces soluble losses.



Treatment of low grade uranium ores hitherto too expensive to refine is being made possible by solvent extraction process. Pilot plant is shown here.

Filtration and moisture control of taconite concentrate was discussed by Henderson, Cornell, Dunyon, and Dahlstrom at the Annual AIME Meeting in New York. Control of moisture was very important in connection with downstream balling and hardening of the taconite pellets. The result of the study was knowledge of the effects of the important operating variables so that these could be controlled to produce consistently good balling. The success of the pelletizing operation at Reserve's Silver Bay plant was in considerable measure due to such control.

Agglomeration and Sintering

Several papers on this important subject will be presented at the Annual AIME Meeting at New Orleans. Alan English and M. F. Morgan will review the subject of downdraft pellet hardening from the original **Allis-Chalmers** research work through pilot plant development and up to current operation at Reserve's Silver Bay plant.

Kurt Meyer of **Lurgi,** Frankfurt, Germany, will describe Lurgi's combination down and updraft pelletizing process. Disks are used for producing green balls without using binder or solid fuel. These balls, of the desired diameter without any intermediate screening, are then fed to the sintering machine by a new handling system. The machine has sections for drying, pre-heating, burning, and cooling. Reaction gases move down draft in the zones, and up draft in the cooling zone.

The green pellets forming a layer 14 to 20 in. deep are deposited on a protective layer of material. For the production of the required heat only gaseous or liquid fuels are burned in a full-length burner hood. By the absence of any solid fuels in the pellets and by producing the necessary heat entirely in the hood, the proper hardening temperature for any ore can be obtained. The material discharging from the pelletizing machine is separated by screening into production and returns.

Pelletizing in a shaft furnace, as developed by **Erie Mining Co.,** will be described by F. D. DeVaney. The shaft furnace has now been under development for a number of years and has proven its advantages in commercial operations.

Progress in the development of an updraft pelletizing method will be described by L. J. Erck. The fundamentals involved in pelletizing hematite as compared with magnetite will be explained.

At the AIME Pacific Northwest Regional Conference in May, W. L. Kendrick described noduliz-

ing at **Manganese Inc.** (MINING ENGINEERING, November 1956). Manganese flotation concentrate of 42 pct grade is agglomerated to produce nodules of metallurgical grade—about 48 pct Mn. The flotation concentrate after filtration contains 18 to 21 pct reagents, consisting of diesel fuel, soap, and oronite, and 20 to 25 pct moisture. Petroleum coke and soda ash are added, and the combined material is fed to the pelletizing kilns, then to the nodulizing kiln where the lead manganate in the concentrate is reduced and then eliminated. Capacity of the nodulizing section is 40 wet tons per hr, representing 22 dry tph of mill concentrate, or 15 tph of 48 pct nodules.

The Malmberget (Sweden) first full scale pelletizing plant has completed a satisfactory year of operation.

Instruments and Control

The control of reagents in flotation on the basis of adsorption theory was discussed at the AIME Annual Meeting in New York by C. H. G. Bushell and M. Malnarich. On the assumption that the amount of reagent adsorbed at a mineral surface must be a function of its residual concentration in solution, it follows that an optimum concentration will exist, not directly correlated to addition rates. For precise control the residual concentration should be used to set reagent additions. The authors used a Beckman spectrophotometer to measure optical density at peak wavelengths as a basis for quantitative analysis of residual xanthate, and standard instruments for pH determinations. They found high correlation between metallurgy and both pH and xanthate concentration. This work is continuing.

Radioactive absorption is being used more widely for measurement and control of a number of process variables. For example: the levels of liquids and solids in tanks, bins, and sumps; the levels of liquid-liquid or liquid-solid interfaces; the specific gravity of liquids and densities of slurries; and the flow of liquids, solids, and mixtures. The absorption of gamma rays is primarily a function of density, but variation in the composition of the measured material may cause erroneous readings. Proper selection of the energy source can reduce these effects. The common sources in use at present are cobalt 60 and cesium 137. A new art of control is being fashioned around radioactive absorption. At the New Orleans AIME Annual Meeting W. C. Knopf will present a paper on the adaptation of the Geiger counter as a control tool in the processing of potash-bearing ores, depending upon radioactive potassium.

The use of pH as a measure of flotation pulp alkalinity is not satisfactory when the measurements occur in a buffered range, or in other words, when a change in addition rate of the reagent does not cause a responsive change in pH. This is especially true in some copper flotation circuits that are operated at high pH, and in these it is customary to titrate the pulp against acid at intervals. With the need for automation the importance of mechanizing this titration has been realized, and the **Industrial Physics & Electronics Co.**, Salt Lake City, this year developed an automatic titrator that is now to be tried out at Anaconda.

The measurement of heavy slurry densities is often complicated by local or random variations in consistency. At the Annual AIME meeting in New York, February 1956, Bernard Rachlin of **Minneapolis-Honeywell** presented the results of development work on the measurement of heavy slurry density and described a displacer system sampling chamber that would maintain slurry at a constant level and at the same time prevent clogging at the bottom. Field tests gave consistent results, promising success for this method in a control system.

Electromagnetic flowmeters, used in the chemical industry for flow control, are now being used in milling control.

Liquid-solids cyclones may be found more adaptable to automation than tank-type classifiers. Thus far, control by size of air core seems to have gained most attention. A recent paper on the subject is "Automatic Control of the Grinding Circuit at the Marmora Concentrator" by P. L. Steffenson and W. M. Aubrey, MINING ENGINEERING, January 1957. The recoverable iron mineral at **Bethlehem Steel Co.'s** Marmora operation is magnetite and the mesh of grind is fixed by the physical requirements of the downstream pelletizing step, not, as is more usual, by optimum mineral liberation for satisfactory concentrate grade and iron recovery. It was decided that the most efficient way to control the grinding circuit (rod and ball mills) was to determine the amount of ball mill circulating load that would give the desired amount of −325 mesh, and then hold the tonnage (not the percentage) of circulating load constant by varying the quantity of new feed.

The vacuum developed inside the cyclone was selected as the intelligence for this system, because it varies with the quantity of apex discharge. A probe extends into this core and at the other end is a controller that positions the tonnage dial on the continuous feed weigher. Output air from the weigher controller positions a rheostat that controls the vibrating feeder on ore. The overflow pipe of the cyclone must be liquid sealed, and the apex must have access to air.

Although successful at Marmora this scheme does not solve the general problem of controlling the percentage circulating load, rather than tonnage.

Control of the grinding circuit at the Reserve concentrator at Silver Bay depends on the feed content of magnetic iron. A sensing mechanism over the feed conveyor is calibrated to increase tonnage when magnetic intensity falls below a certain point, and vice versa.

A paper that is awaited with some interest is "Automatic Controls and Milling Operations" by H. E. Uhland and W. Barbarowicz of **International Minerals & Chemical Co.**, a firm that has contributed much to this art. The paper, to be presented in February at the AIME Annual Meeting at New Orleans, will describe instrumentation and methods for controls of pump speeds, hydroseparator underflows, levels, feed rate, reagents, dryers, and blending.

The Littlewood ball mill feed automatic control developed and used at **Cananea** (U. S. Patent Application 228,181) utilizes the power input characteristics of the equipment that limits the capacity of the circuit. This equipment may be mill or classifier or both. Each of these four characteristics is used: amount of power at optimum condition, rate of correction, direction of correction, and amount of correction. Water control is limited to use of a motorized pinch valve to control the water going to the classifier itself.

Report on Research

Howe Sound Co.'s new central research laboratory at Salt Lake City.

The new central research laboratory of the **Howe Sound Co.** at Salt Lake City was completed in August. This location was selected because of its proximity to the Garfield cobalt refinery of Calera Mining Co., a Howe Sound subsidiary, and also because the area is reasonably well supplied with technical personnel and it is generally convenient to other Howe Sound activities.

The laboratory building contains 8000 sq ft of usable space divided into six general areas: office and library, pyro- and physicometallurgy, hydrometallurgy and mineral dressing, machine shop, instrumentation laboratory, and analytical laboratory. Future expansion was a design consideration.

Research in the near future will be largely confined to cobalt. A pilot plant for production of high purity electrolytic cobalt has been in operation several months, and a full scale unit is now in construction at Garfield on the basis of this work. Projects in the offing are: fundamental work on the flotation of cobaltite and related minerals; chemistry of the acid oxidation autoclave system of high temperature hydrometallurgy; and a study of cobalt-base alloys.

The new Ore Research Building of the **Michigan College of Mining and Technology** was opened on the campus in August. A 132x55-ft section of the building is divided into 17 laboratories, and an 82x50-ft section is to be used for pilot plant investigations. M. E. Volin, director of the new facility, stated that supplying an increasing tonnage of merchantable ore to the Michigan iron and steel industries is one of the most pressing problems to be investigated.

In cooperation with the **Minnesota Mines Experiment Station** the University of Minnesota, University of North Dakota, and Great Northern RR are sponsoring research to discover an economical method of concentrating nonmagnetic taconite on the Mesabi Range.

Newmont Exploration Ltd. is building a laboratory in Danbury, Conn., for geophysical and minerals beneficiation investigations. Completion is expected in February 1957.

More Federal help towards keeping our mining industry healthy and making the U. S. more self-sufficient in critical and strategic minerals seems to be taking shape. The U. S. Bureau of Mines is in line for additional funds, and undoubtedly minerals beneficiation research will come in for its share.

Realization of the importance of research is not confined to this country. In Sweden the future of mining will depend greatly upon advances in minerals beneficiation. The research facilities of the country have therefore been increased at the central research laboratory of the **Royal Institute of Technology** in Stockholm, and also at the larger mining companies. This year **Boliden Mining Co.** started a new research laboratory, replacing an older one put in ten years ago. New, smaller research laboratories have been established at Stripa and Strossa.

The following section of the beneficiation review is organized under commodity headings.

Michigan's first state-supported mineral research laboratory is represented by the Ores Research Building at Michigan Tech. It will serve as headquarters for college's Bureau of Mineral Research.

Developments by Commodities

Uranium

U. S.: Activity continued to accelerate in the western U. S. (and in Canada). **The Mines Development Co.** mill at Edgemont, S. D., and that of the **Uranium Reduction Co.** at Moab, Utah, started operations using the acid leach resin-in-pulp process. Construction was started on the new mills of the **Texas-Zinc Minerals Corp.** at Mexican Hat, Utah, and the **Dawn Mining Co.** in Stevens County, Wash. The Texas-Zinc mill plans to use sulfuric acid leaching followed by solvent extraction, and the Dawn mill plans to use sulfuric acid leaching followed by ion exchange columns. **Union Carbide Nuclear Co.** plans to build two upgrading plants, one at Slick Rock, Colo., and the other at Green River, Utah. In addition to these, Union Carbide will build a new mill near Rifle, Colo.

Construction is expected to start before the year's end at the plants of the **Lucky Mac Uranium Corp.** and that of the **Lost Creek Oil & Uranium Co.,** both in the Gas Hills-Crooks Gap area of Wyoming. Both mills will acid leach, with the Lucky Mac mill using column ion exchange and the Lost Creek mill using resin-in-pulp.

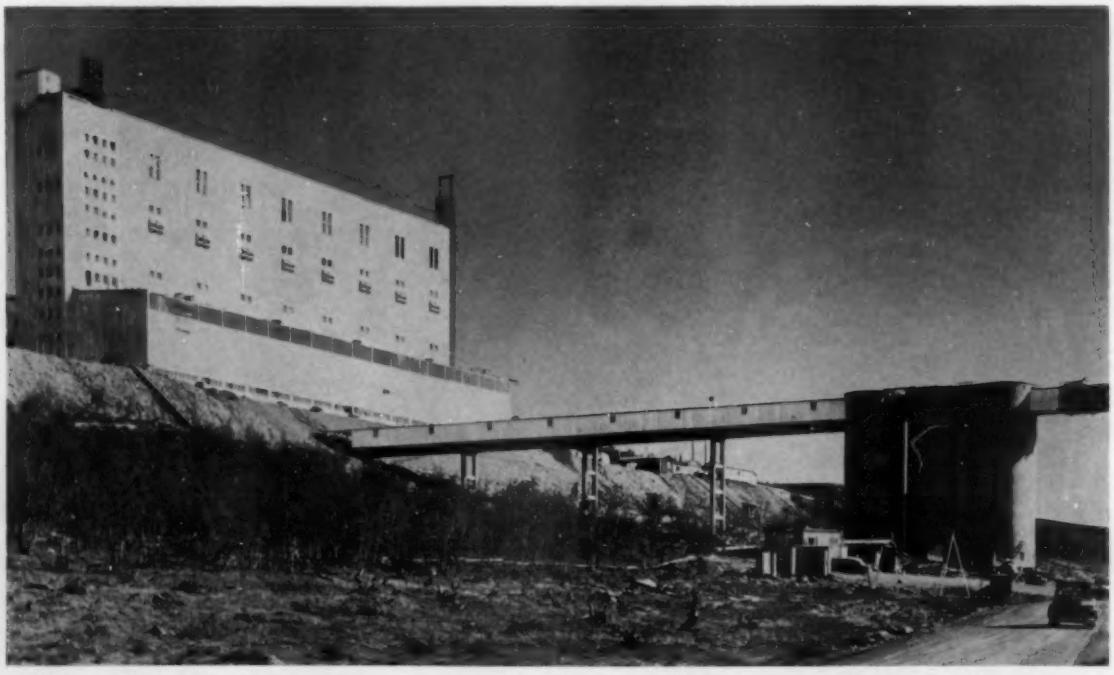
A bit of historical contrast is offered by the news that the old **Pioneer Carissa** cyanide gold mill in Fremont County, Wyo., will be converted to a carbonate leach uranium processing plant.

Uranium Reduction Co. will add a carbonate leach system to its new mill now under construction. **The Ute Milling Co.,** subsidiary of **Atlas Corp.,** plans a concentrator at La Sal, Utah, to serve the Big Indian district.

Three mills on the Colorado Plateau were operating solvent extraction processes either on a plant scale or semi-plant scale, and all are reported to be working satisfactorily.

With the use of new flocculating agents the need for the resin-in-pulp process on slimy ores has diminished, and interest in either ion exchange columns or solvent extraction using organic phosphates or the amines has increased. Choice of either of the two processes depends, to a large extent, upon characteristics of the ore which might cause resin fouling in the ion exchange columns, or cause emulsion formation in the solvent extraction process.

Carbonate leaching, either with or without pressure, of even low lime ores was given increased attention. Laboratory work on the uraniferous lignites indicated that burning of the lignite prior to leaching will be required to decrease acid consumption and increase recovery. With the increasing demand for vanadium,



European counterpart of U. S. taconite and jasper operations is found in Swedish magnetic ore beneficiation operations such as this new plant at Kiruna, Sweden.

attention was again given to possible recovery of vanadium from the carnotite-type ores, even at the mills where vanadium recovery was not initially considered as a part of the flow sheet.

A great many people were giving serious consideration to production of uranium products beyond the concentrate stage. Whether or not a mill of reasonable size could produce products such as UO_3, UF_4, or UF_6 is principally a matter of economics.

A large amount of work was done at government-sponsored research laboratories, privately-sponsored research institutions, and company-owned laboratories throughout the continent on metallurgy of uranium ores. A new process called the *eluex* process was developed by the National Lead Co. as contractors for the Atomic Energy Commission at Grand Junction, Colo. This process, which involves sulfate elution of resin followed by solvent extraction with organic phosphate and stripping of the organic with carbonate solutions, appears to offer some possibilities of reduced costs.

CANADA: Uranium industry construction was the highlight of the year. Uranium mills from 500 to 5700 tpd were under construction. The government-owned **Eldorado** plant at Beaverlodge was undergoing extensive changes in metallurgy and also expansion. Pressure leaching was abandoned in favor of basic leaching in Pachucas with longer time of contact. **Gunnar** and **Pronto** tuned up plants which had started in 1955, and have made minor alterations such that original capacity is now exceeded.

Two new mills went into production. In Blind River, **Algoma-Quirke's** 3000-ton plant went into operation. In Bancroft the **Bicroft** 1000-ton plant started successfully. Both these plans use C.C.D. wash plants instead of two-stage filtering. At Bicroft the grinding is done by open-circuit rod-milling, followed by pebble milling with screened ore. In an acid leach process the savings in chlorate, acid and steel amount to 30 to 40¢ per ton milled over conventional ball milling.

In 1957 uranium acid leach plants will be in operation at **Algom-Nordic** (3000 tons), **Consolidated Dennison** (5700 tons), **Can-Met** (2500 tons), **Northspan's** three mills (Lake Nordic 4000 tons, Panel 3000 tons, and Spanish American 2000 tons). These are all in the Blind River area. In Bancroft, **Faraday's** 1000-ton plant is expected to start in March. In the West, **Lorado's** 650-ton custom mill and **Rayrock's** 150-ton mill will be running in the spring.

The declassification of uranium processing allowed several companies to publish papers on their uranium chemistry. The Eldorado plant of the Government at Port Radium was described.

The importance of the use of flocculating agents in the treatment of acid pulp was demonstrated during this year to such an extent that it changed some of the thinking on equipment and processes.

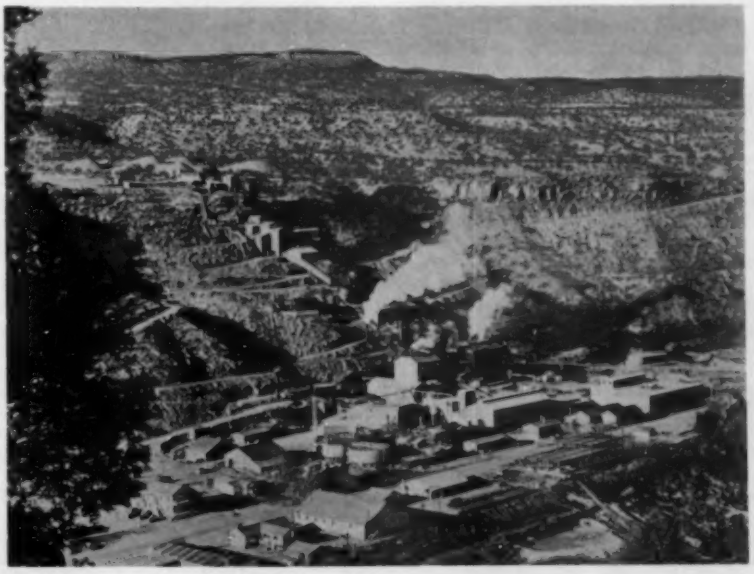
Flotation concentration to reduce capital and operating costs in the leaching section was the subject of several papers. Writing on this subject in the *CIM Bulletin*, February, T. V. Lord and D. E. Light declared that the full possibilities have not yet been resolved and that new ores should be examined for flotation response. John N. Butler and R. J. Morris presented a paper at the AIME Annual Meeting in New York on the flotation of secondary uranium minerals, and at the same meeting Burt Mariacher described tests on primary uranium ores.

ION EXCHANGE: Writing on the important role of ion exchange in uranium production were R. Kunin and A. Preuss in *Ind. & Eng. Chem.*, August; A. B. Mindler and J. P. Termini in *E&MJ*, September. At the annual AIME meeting in New Orleans W. C. Hazen will describe a C.C.D. solvent extraction plant that has been operating for some months at Kerr-McGee's Shiprock Mill on 100 gpm of acid leach liquor. K. B. Brown will describe some new solvent extraction processes, particularly the Amex (amine) and Dapex (dialkylphosphoric acids) processes. James A. Barr will speak on extraction of uranium from phosphates.

At the same meeting E. S. Porter and H. G. Petrow will discuss the recovery of uranium from uraniferous lignites. Roasting appears to be necessary, and most ashed lignites require large quantities of acid for the leach. Several methods for recovery from the leach solutions will be described.

In the category of general and review articles William Lennemann presented a paper at the AIME annual meeting in New York; J. B. Rosenbaum and J. B. Clemmer, together with Mr. Lennemann, wrote about innovations in processing uranium ores for the Rocky Mountain Minerals Conference at Salt Lake City, and another excellent review by R. A. Foos appeared in MINING ENGINEERING for September.

At the American Mining Congress meeting in Los Angeles, October, E. C. Peterson and D. C. Matthews described Anaconda's Bluewater plant. R. S. Olson spoke on the application of solvent extraction, C. K. McArthur and E. H. Crabtree spoken on research and new developments, and use of solvents was covered by Woodrow Knott.



Starting from two plants in 1947, U. S. treatment of uranium ores has boomed in a decade with more than a dozen plants in operation plus others planned or under construction. Uravan, Colo., mill of Union Carbide Nuclear Co., shown here, was one of earlier plants with first installation for uranium dating to 1950. Processes in these plants are adding new hydrometallurgical techniques, such as ion exchange and solvent extraction, to the inventory of unit operations available to beneficiation designers of the future.

Iron Ore

Marquette Iron Mining Co.'s Republic mill, a jasper concentrating unit on the Marquette Range of northern Michigan, started operations in April 1956. The 600,000 long ton ore capacity plant has a flow sheet similar to Humboldt's: fine grinding and flotation. Crushing is in three stages, gyratory and Symons standard and short head cone crushers, to pass ½ in. Two grinding circuits, each comprising a 9x12-ft rod mill and 11-ft ball mill, the latter in closed-circuit with a 14-ft Hydroscillator, reduce the ore to pass 65 mesh. A sand-slime separation is made in cyclones, the very fine overflow going to tailing, and the thickened underflow going to conditioners and then flotation. The concentrate carries 63 pct Fe and 8 pct SiO_2.

This product is rail shipped to Eagle Mills, some 32 miles distant, for agglomeration. First the concentrate is reground to 65 pct —325 mesh, then thickened and filtered, next combined with bentonite and ground limestone at the balling disks. Ground coal is added to the disk near the outer edge. The green pellets range in diameter from ⅜ to ½ in.

Pellets are heat-hardened in a McDowell updraft sintering furnace. The grate conveyor is 6x223 ft; grate speed is 30 in. per min. The first 168 ft is the firing zone, and the remainder the cooling zone. Return pellets are used for the hearth layer. Four 8-in. layers of pellets are successively deposited and ignited. The first shipment of 5000 tons of these pellets left Ishpeming, Mich., for Chicago the middle of September.

Expansion of the Humboldt mill is under consideration.

Cleveland-Cliff's research laboratory in Ishpeming is working towards magnetic oxide conversion of these Marquette Range jaspers by roasting, which would permit use of the lower cost magnetic concentration employed on the taconites.

MESABI: The E. W. Davis taconite plant of **Reserve Mining Co.** at Babbitt and Silver Bay, Minn., was officially dedicated on Aug. 9, 1956. The new crushing plant at Babbitt and the first section of the concentrator were started in October 1955, and pellet production began a few days later. A number of excellent articles have already appeared on these outstanding installations, designed to produce 3.75 million long tons of taconite pellets per year.

The new **Erie** concentrator near Aurora, with annual capacity of 7.5 million tons of taconite pellets, is nearing completion, and initial operation is expected by mid-1957.

Jones & Laughlin's lease of Quebec Cobalt's iron ore deposit will probably lead to another important chapter in the beneficiation of iron ore. The Quebec deposit is said to contain 32 pct iron in the form of coarse hematite.

Hilton Mines, 40 miles northwest of Ottawa, are constructing crushing, milling, and agglomerating plants for annual production of 600,000 tons of high grade pellets. This is a low-grade magnetite ore. Rod and ball mill grinding will be followed with magnetic separation, balling, and firing of pellets to 66 pct final grade. Completion is expected in 1958.

Oliver completed a Humphreys spiral plant at midyear to recover fines from the present wash classifier overflows at the Plummer mine.

The Minnesota Iron Mines Div. of **Jones & Laughlin** is building a plant at Calumet for the recovery of iron from fine tailings accumulated over a 35-year period. The process will be a combination of gravity concentration with Humphreys spirals, and froth flotation. Completion is scheduled for April 1958.

The Trout Lake plant of **Oliver** at Coleraine, first operated in 1910, will be given a new heavy media section using separators on the +¼ in. and cyclones on the —¼ in. When completed the plant will have capacity for 1600 ltph.

The Mahoning mine of **Pickands, Mather** is putting in a washing, heavy media, cyclone, and spiral plant at Hibbing, to be ready for the 1957 season. Other heavy media additions on the Mesabi are at Webb and Troy.

(For the following notes we are indebted to L. J. Erck of Cleveland Cliffs Iron Co.)

"Froth flotation on iron ores is still directed towards the dense form of hematites. Earthy or limonitic types still present technological problems as to reagents suitable for selective flotation. The two operating flotation plants, Humboldt and Republic, located in the Upper Peninsula of Michigan, are unique. All other endeavors have proven to be marginal, or generally favorable.

"Investigations are still in progress at various research institutions to discover or create reagents applicable to ores containing iron in the form of limonite, goethite, and hematite mixtures. There have been several flotation schemes developed in the laboratory, both cationic and anionic, or duplex systems of these, but so far the schemes that have emanated from such developments have proven to be only partly effective under very close control of pH, slime elimination, solids conditioning, etc. It can therefore be said that so far flotation has only worked where the mineral is a dense hematite such as specularite, having a high degree of mineral homogeneity.

"Investigations into the subject of magnetic oxide conversion, or conversion of nonmagnetic oxides to artificial magnetite, are being carried on in the Lake Superior district with varying degrees of interest and intensity. It is recognized that the established flowsheets used on the Minnesota taconites and the Canadian magnetites are adequate for those ores, but there exist tremendous reserves of ores that are not magnetic and that do not respond very favorably to flotation either. This fact, together with the need for higher-grade blast furnace feed, emphasizes the importance of magnetic oxide conversion.

"A one-ton-per-hour FluoSolids Reactor is now being operated in Michigan by **The Cleveland-Cliffs Iron Co.** with auxiliary concentration equipment using the conventional magnetic separators to study the overall problem. Other conversion vessels also applicable and being considered are the rotary kiln and shaft furnace. The chemistry of conversion in all instances is the same, with the points of interest being the degree of reduction and the thermal efficiency.

"The problem of concentrating artificial magnetite may necessitate the reviving of the design research on magnetic separators because of the different response between artificial and natural magnetite. Several types of magnetic separators are being examined in the Cleveland-Cliffs pilot plant in order to investigate the concentrating characteristics.

"The high intensity principle of the Carpco Separator has demonstrated that on iron minerals of high density such as specularite, efficient separations can be made. Capacities and economies have yet to be worked out by way of continuous operation in a pilot plant of adequate capacity for establishing applicable correlation factors to commercial installations.

"Both **Aerofall Mills Ltd.** and **The Hardinge Co.** have had pilot plants set up at several research laboratories and mill locations in the Lake Superior district to study the possibilities of applying this form of autogenous grinding to the lean ore horizons. So far, plant design has adhered to the conventional stage crushing with gyratory and cone crushers and interstage screening. The ability to combine the second through fourth stage crushing, also rod milling, make such an operation attractive if metallurgical results are at least equal. Consideration is being given to several installations both in the Lake Superior District and in Canada. The final decision will have to await the outcome of fundamental studies.

"The iron recovery plant of **International Nickel** at Copper Cliff, Ont., is now in operation and producing pellets. This is the first plant of its kind in operation and differs in the respect that former plants extracting nickel made no effort to recover the iron content of the ore. In this operation the iron, originally in the form of a pyrrhotite, is converted to an artificial magnetite from which the nickel content has been extracted by ammonia leaching. It has been stated that this plant cost $90 million and will treat 1000 tons of pyrrhotite daily. After this plant has been brought to full capacity, expansion is planned to permit an ultimate annual production of about 1 million tons of iron ore pellets.

"**The Cleveland-Cliffs Iron Co.**, in their Canisteo plant at Coleraine, Minn., are introducing abrasion milling or scrubbing of the crude ore preparatory to screening and washing for heavy media separation. The laboratory work has indicated that scrubbing of the material improves the separating qualities of the iron ores and that more effective separations can be made by heavy media, thereby improving the grade of the iron ore concentrates as well as increasing the recovery. The scrubber for this plant was designed and built by the Hardinge Co. of York, Pa."

CANADA: The iron ore fields of Quebec and Labrador are being studied intensively with regard to tonnages, methods of treatment, and details of shipping procedures. It is now believed that concentrates can be shipped from Arctic ports during the summer months to a trans-shipping point in Greenland, where year-round ice-free ports are available.

In the Ungava district, **International Iron Ore Co. Ltd.** and **Consolidated Fenimore Iron Mines Ltd.** are finalizing plans for development of their deposits, while near Seven Islands, **Canadian Javelin Ltd.** plans a concentrator, with the concentrates being hauled to the St. Lawrence River over the Iron Ore Co. of Canada's Seven Isles to Knob Lake railway.

Aconic Mining Corp. has started operation of its 4000-ton pilot plant to treat magnetite-ilmenite sands at Natashquan, Que. Product is a magnetite concentrate for sale in Europe.

A 10-tpd pilot plant has been constructed by **Marcona Mining Co.** and Utah Construction Co. at San Juan on the coast of southern Peru with the possibility of installing a commercial beneficiation plant. Among other research projects, the effect of sea water on milling processes and equipment is being studied.

From France: During the past year the French Research Institute of the Iron and Steel Industry (IRSID) pursued research work on preparation of French iron ores and particularly of low grade self-fluxing Lorraine iron ores called *minette*. The preliminary planning of the first concentrator using high intensity magnetic separation is now being made and further work is considered in conjunction with open pit mining for big capacity beneficiation plants. Progress is being made in agglomeration, and several sintering and nodulizing plants are being built to bring the annual capacity from 1.8 millions metric tons in 1956 to 8 or 10 millions tons in 1960.

Copper

The high price and great demand were reflected in unusual activity in the copper concentrators. There was hardly a plant without some progress to report this year.

U. S.: The new copper concentrator of the **San Manuel Copper Corp.** at San Manuel, Ariz., has attracted more than usual interest in its first year of operation. One 4000-ton section was started in October 1955 on dump ore stored from mine development. By late 1956 five of the eight sections were in operation, all of these on mine ore produced by block caving. Although it is too early to predict the eventual tonnage rate and metallurgical performance it can be said that this fine mill is already living up to expectations based on laboratory and pilot plant experimentation. A complete description of the plant was published in *E&MJ* April.

The ore is not crushed until it reaches the two 7-ft Symons standard cone crushers with feed opening of 17½ in. The product of the four short head crushers that follow is −1½ in. and this is the rod mill feed. The whole crushing operation from the railroad bins to the fine ore bins is controlled at a central panel on the single operating floor of the crushing plant.

For the flotation of molybdenite from the copper concentrate sodium hypochlorite is used to tarnish the chalcopyrite. San Manuel uses this oxidizing reagent in place of heat for this purpose.

The **Pima Mining Co.'s** mill south of Tucson expects to go into production in early 1957. The crushing plant has conventional equipment consisting of a primary jaw crusher (Birdsboro 66x84), a 7-ft standard Symons cone secondary crusher, and a 7-ft short head Symons cone tertiary crusher. The crusher arrangement has been planned to crush 3500 tons in a one 8-hr shift. All material will be reduced to pass a 1-in. sq opening screen, the screens being two Ty-Rock F-900 double deck units in closed circuit with the tertiary crusher. The one shift capacity was so designed that future mill expansion may be handled by operating the crusher a second shift.

The mill has a design capacity of 3000 tpd. Ahead of it will be two fine ore silos with total capacity of 6000 tons. Gathering conveyors will deliver the 3000 tpd to one rod mill (10½x13) operating in open circuit at about 63 pct of critical speed. Rod mill discharge will be pumped to two batteries of three cyclones (Equipment Engineers, 20 in. diam) at 10 to 15-psi inlet pressures. Cone overflow, at about 70 pct −200 mesh, will go to flotation. Cone underflow will go to two 10½x12 ball mills, each mill being in closed circuit with one battery of cones and turning at about 63 pct of critical speed. Ball mill discharge will join the rod mill discharge and be pumped to the cyclones. No mechanical classifiers are being installed, although space has been left for them in case cyclone pump wear is excessive because of tramp oversize in the rod mill product. If such wear occurs, a rake or screw can be used to send the coarse fractions direct to the ball mills.

Cyclone overflow will be split between three lines of rougher and scavenger flotation cells. Rougher concentrate will be cleaned and recleaned in two successive lines. All cells will be 66-in. Fagergren units. A 7x12-ft regrind mill will handle middlings from the scavenger, cleaner and re-cleaner cells. Alternate arrangements are available for regrinding rougher concentrates. Cyclones will be used for regrind classification.

The **Anaconda** mill is completing the installation of three 10x14-ft rod mills and three 10x12-ft ball mills, adding approximately 11,000 tons daily capacity to the west mill. Experimentation with cyclones is continuing. At **White Pine's** new concentrator rod mills are being added to prepare finer feed for the large ball mills.

The **Silver Bell** mill of AS&R Co. near Tucson added a molybdenite flotation section early in the year.

The re-equipment of **Inspiration's** mill near Globe, Arizona, proceeded through 1956. All of the old grinding and flotation equipment has been removed and is being replaced with seven 10½x14-ft grate discharge ball mills, seven 16-ft rake classifiers, twelve rows of 12 rougher cells, and four rows of 5 cleaners. Outside the mill, two 275-ft diam traction thickeners for flotation tailing are being built, and tailing dams of approximately 300 acres are being prepared. When rehabilitation is complete early in 1957, the Inspiration leaching plant will convert from the ferric sulfate leaching process at 11,000 tpd to a straight sulfuric acid leach at 16,000 tpd. The sulfide copper remaining in the leach plant tailing will be recovered in the concen-

trator by regrinding and floating in a conventional acid circuit.

Appalachian Sulphide Inc., a Ventures Ltd. operation, is developing a copper mine at West Jefferson, N. C., on the old Ore Knob property in the northwest corner of the state. Company is building a 700-ton mill and expects to have the first 350-ton unit in operation early in 1957. At first the company will produce only a copper concentrate, but later hopes to produce a saleable iron concentrate also.

The **General Chemical Co.** is operating a pilot plant to recover copper from its Galox ore in southwest Virginia, worked many years for its sulfur. The company upgrades about 500 tpd of 26 pct sulfur ore to 35 pct sulfur by a dry gravity process. The plant has never recovered the copper or zinc.

CANADA: The Granby Consolidated Mining, Smelting & Power Co. is proceeding with the construction of a mill at Phoenix, B. C., to treat copper ores from the old Phoenix mine. The mill capacity is reported to be 500 tpd.

Lindhurst Mining Co. Ltd. went into production early this year using the mill of Beattie Gold Mines which has been changed over for copper flotation. Milling rate is between 400 and 500 tpd. **Rainville Mines Ltd.** also has gone into production at 400 tpd on a copper-gold ore.

In the Chibougamau area, **Chibougamau Explorers Ltd.** came into production with a 500-ton mill treating a gold copper ore. The ore assays 0.31 oz gold per ton and 0.80 pct copper with recoveries of 92.6 and 91.6 pct respectively.

Eastern Mining & Smelting Corporation Ltd., which is managed by Mogul Mining Corp., has a smelter under construction at Chicoutimi, Que., to treat copper and nickel concentrates. Copper will be produced by the Outokampu flash smelting process and nickel will be produced by the Sherritt Gordon ammonia-leach process. In the Eastern Townships area of Quebec, **Eastern Metals Corp. Ltd.** is planning construction of a mill to treat a copper-nickel ore.

In Newfoundland, **Maritimes Mining Corp. Ltd.** has begun construction of a 3000-ton mill which is expected to go into production early in 1957. The property is an old copper mine at Tilt Cove, which was operated last in 1917.

SOUTH AMERICA: The Toquepala project of the **Southern Peru Copper Co.** (AS&R, Newmont, Cerro de Pasco, and Phelps Dodge) entered the construction phase this year. The 30,000-tpd copper flotation concentrator will receive ore from the Toquepala open pit mine, crushing to 8 in. in a 60-in. gyratory crusher, then to 15 pct +¾ in. in two stages of cone crushing. The ore will be ground to 9 pct +65 mesh, first in seven 10x14-ft rod mills and then in fourteen 10½x13-ft ball mills, using conventional classifiers. The +200-mesh portion of the rougher concentrate will be reground in seven 8x13-ft ball mills, using cyclones in closed-circuit. Two stages of cleaning will be followed by dewatering and partial drying of the concentrate.

The classifiers in the rod and ball mill circuits are so arranged that wet cyclones can be installed later, if desired, by replacing two 8-ft rake classifiers in each grinding section.

The lime required in flotation will be obtained from coquina beds south of Ilo. The mixture of shell and pebble, cemented with sand and salt, will be blade-milled and washed on screens, then calcined in a kiln located at the smelter.

At Potrerillos in Chile, **Andes Copper** is developing the Salvador mine, a large low grade deposit of mixed ores, with molybdenum, to replace the present mine which has a very short life remaining. At first it was planned to use the present concentrator, smelter, etc. to treat the ore which would be crushed at Salvador and transported to Potrerillos by belt conveyor. However, recent reports are that a new concentrator will be built at Salvador, and a new roasting and smelting plant there, or possibly on the coast, and the present plant at Potrerillos will be used only to treat the remainder of the ore in the old mine.

Originally, the proven ore reserves of El Salvador were announced as 78 million tons, averaging 1.6 pct copper. However, additional drilling and development work have increased the estimated tonnage to 200 million tons of this grade.

At the Cerro mine of **Cerro de Pasco** in Peru the mine drainage waters containing soluble copper with a high percentage of iron have been treated underground and on the surface by cementation with scrap iron. After research by the Oroya research department staff it was decided to build an experimental ion exchange plant to test the use of ion-exchange resins for recovery of copper from the Cerro Mine waters. This ion exchange pilot plant went into operation in the middle of 1956 and has a capacity of 100,000 liters per 24 hr. The pH of the mine waters averages about 2.5 and the ratio of copper to iron is in the neighborhood of 1 copper to as high as 30 iron. The successful future termination of pilot plant experimentation would lead the way to a full-scale plant.

At **Mauricio Hochschild & Co.'s** Mantos Blancos property, inland from Antofagasta, Chile, operation of a 5-tpd pilot plant has been started to treat a copper ore containing copper chlorides and phosphates. The process involves percolation acid leaching with precipitation of the copper as cuprous chloride while regenerating acid by treating the hot solutions with SO_2. Application of ion exchange, reduction of cuprous chloride by smelting with limestone and coal, and electrolysis of dechloridized leach solutions are all to be investigated on pilot plant scale. Construction of a full scale plant will start in 1957.

At the Rosita copper property of **La Luz Mines** in Nicaragua work is being completed preliminary to installing a 600-ton plant for leach-precipitation-float treatment. A Fluosolids roaster will be installed and the SO_2 will be used to make weak sulfuric acid by the Keyes process.

Kennecott completed extensive improvements at its Braden mill in Chile early in the year. Ten Symons crushers, four primary and eight secondary grinding mills were added. The flotation section was modernized by nearly complete replacement of the old MS flotation cells with Fagergrens. The mill averaged nearly 36,000 tons per day in March 1956. Cyclones are being studied for various purposes: for obtaining clear water from flotation middlings to reduce pumping; for separating very fine material from concentrates to relieve filters; and for separating coarse material in the first ball mill circuit to avoid excessive pumping.

In the Philippines the **Marinduque Iron Mines Agents Inc.** is planning a 3000 to 4000-tpd concentrating plant at the Sipalay copper mine in Negros Occidental. Average grade of ore is 1 pct copper. **Mindanao Mother Lode's** new 400-ton copper flotation mill at Cabangan, Zambales, went into operation at midyear.

In North Africa a new copper mine is being developed by the **Societe des Mines de Cuivre de Mauritanie** (Micuma). The mine contains 18 millions tons of sulfide ores with 1.5 pct copper and 8 millions tons of oxidized ores with 2.40 pct copper. The sulfide ore will produce a flotation concentrate with 28 pct Cu and a magnetite concentrate containing 70 pct Fe and only 0.1 pct Cu. The oxidized ores present a difficult problem as they yield poor results by flotation or leaching. A pilot plant is being erected for study of the problem.

(The following notes on developments in the important copper belt of Northern Rhodesia were contributed by Max Goldick of Roan Antelope.)

NORTHERN RHODESIA: Despite an appreciable amount of industrial trouble involving the African mine workers, boom conditions continued throughout the year on the Copper Belt, with the four major producers operating at capacity.

The **Anglo American Group** is well advanced with the development of its rich Bancroft property, close

(Continued on page 238)

Developments in Education

The following is contributed by A. C. Richardson, Chairman of MBD's Committee on Education.

The demand for graduate engineers with training in minerals beneficiation (under which term I include hydrometallurgy and certain phases of pyrometallurgy) greatly exceeds the present and potential supply. This is serious but of greater significance is the fact that although there has been an increase in the enrollment of engineering students, the enrollment in metallurgy and particularly minerals beneficiation has not been in proportion to the demand nor the increase in other fields of engineering. It is significant that it is possible to fill some positions that normally would be filled by beneficiation engineers with chemical engineers, who lack specific training in mineral dressing which they must acquire on the job. This may be taken to indicate that minerals beneficiation has opportunities that equal or exceed chemical engineering, and if these opportunities are more widely known, the number of engineers trained in minerals beneficiation might be appreciably increased.

One factor that has helped to increase the enrollments in engineering has been the financial aid received from industry. This may be in the form of scholarships offered to students, grants to technical schools or both. Several of the large chemical and electrical companies have well-organized programs of this nature. This method of encouraging engineering education is supported to some extent by the mineral industry and it is expected to increase.

In discussing with prospective employers the type of training they prefer graduate engineers to have, an increasing number seem to prefer that the engineer have a sound, broad working knowledge of scientific and engineering principles rather than detailed information on specific applications of limited fields of knowledge. This indicates an acceptance of "on the job" training for the employers' specific needs. Most employers have expressed a need for the development of initiative and good judgment or "horse sense."

Interviews with students of superior ability indicate that many of them believe that their future advancement, professionally and financially, will be more assured if they have advanced degrees. This view naturally leads them to enroll in those courses that lead to, or are required as a basis for, advanced degrees. Furthermore, when engineers at the B.S. level seek employment, it is assumed that there will be "on the job" training and considerable attention is given to the opportunities a job offers for additional study that may lead to advanced degrees. The type of student who a few years ago was satisfied with the opportunities available to a man with a B.S. now feels the need for an advanced degree.

It would appear then that in at least certain areas, the ambitions of students and requirements of industry are compatible. I believe that our technical schools, considering budgets, available faculty, etc., are doing a good job of imparting to the students the scientific principles which form the basis for the various fields of engineering. It is the application of these principles to practical problems or the ability of young engineers to use "horse sense" that seems to bother most employers, although it seems to me that the situation is not as bad as indicated, and in many cases, "horse sense" is a synonym for experience.

The technical schools try to supply this experience and to develop judgment in the application of scientific knowledge through laboratory experiments and the so-called practical courses. It is in these courses that the student learns how to use scientific theory and gains the confidence necessary for attacking a new problem. The problem that confronts the technical schools is to decide how much emphasis to place on practical courses as compared with the theoretical courses. I believe that most schools offer an adequate number of practical courses and that most experience must be gained in industry after an engineer leaves school.

For example, the "Laboratory Experiments in Mineral Dressing" compiled by last year's MBD Educational Committee certainly gives a student all the experience in the application of scientific principles industry can expect from a technical school. Most schools also are offering courses that afford experience in the reducing and sulfate roasting of ores as well as work in leaching at elevated temperatures and pressures.

Because of the need for more trained personnel in industry, some thought has been given to the possibility of a technical school beyond high school in which the study of a relatively small amount of scientific theory is supplemented with a large amount of work on the application of engineering techniques to practical problems. A course of this nature would perhaps require two years to complete and might hold considerable attraction for intelligent, capable high school graduates who for some reason do not have the aptitude or opportunity for the conventional technical education.

Although there is practically no phase of technical education that cannot be improved to a marked degree, both schools and industry are cognizant of the fact and are working to better the situation, although the progress is not as rapid as desired. It is desirable to improve the quality of our engineers, but under present conditions, we would be very happy if we had many more of the present quality.

To this we add that as long as the technical school is compelled to take time out to teach such high school subjects as algebra, trigonometry, analytical geometry, English, history, and foreign languages, the quality of its graduates will suffer, and industry must mend the deficiency.

(Continued from page 236)

to the Belgian Congo border, and production is scheduled for January 1957. Initial throughout will be 150,000 tons per month, with eight grinding units, but this will be doubled later. Instrumentation has received considerable attention and tonnage rate control will be automatic. Single stage grinding is provided for, using only hydrocyclones as classifiers.

N'Changa, with a present capacity of 280,000 tons throughput per month using eight grinding units, is adding two more grinding units to increase capacity by 25 pct. Classification on three of these will be by hydrocyclones. Additional flotation capacity is also being installed. The upper N'Changa ore body, which is virtually all oxide, is being opened up by open-cut and the ore from this deposit is to be treated separately from the mixed oxide-sulfide ores currently milled. It is anticipated that delivery of ore from the open cut will commence next January.

N'Kana, which is milling about 360,000 tons per month, in common with the other Copper Belt concentrators has been experimenting with hydrocyclones as classifiers in the grinding circuit.

Kansanshi, an old property which is situated away to the west of the main Copper Belt and close to the Belgian Congo border, is being investigated by Anglo-American and a small treatment plant is being erected there.

Mufulira, of the Selection Trust Group, now has 16 grinding units in operation and is milling at the rate of 360,000 tons per month.

At **Roan Antelope,** an extensive program of plant additions was completed during the year and capacity was stepped up to 450,000 tons per month, which is the highest tonnage rate for Africa. Single stage grinding is used with two stages of classification—the original mechanical classifiers in the second stage of classification are being replaced by hydrocyclones.

Chibuluma Mines, Ltd., a copper-cobalt proposition situated about ten miles from N'Kana, went into production in May with a milling rate of about 45,000 tons per month. This is the first new mine to start up since the war.

The directors of the Selection Trust Group have made known their intentions of increasing Mufulira output by 50 pct, probably involving the construction of another concentrator. The **Chambishi Mine,** which lies about mid-way between N'Kana and N'Changa, will probably also be opened up.

Off the Copper Belt, a small amount of copper concentrate is produced by the **Mutuga** mine, some 60 miles from Kapiri Mposhi on the main railway line. Active prospecting is being continued over a large area of the territory:

This year's production in Northern Rhodesia will reach about 380,000 long tons of copper, placing it near Chile for the number two producer. Completion of the first phase of the giant Kariba Gorge hydroelectric power project will pave the way for an expansion of about 40 pct in Northern Rhodesia's copper production by 1960.

Lead and Zinc

The Jefferson City mill of the **New Jersey Zinc Co.** was completed and the shakedown started on Aug. 28, 1956. This modern mill is located near the town of Jefferson City, Tenn. Designed for a feed rate of 45 tons per hr, it incorporates many up-to-date ideas in milling practice. The mill building has no windows; lighting is fluorescent and mercury vapor for the operating sections. The building is of structural steel covered with insulating board and galvanized siding.

Ore from the mine is received by the mill at the skip bin at approximately —14-in. A 1200-ton surge tank is located intermediate between the skip bin and the mill. In the mill the ore is reduced to —⅝ in. by a Symons 5½-ft Short Head Crusher operating in open circuit with a double-deck Tyler Tyrock screen. Crushed ore is stored in a suspension bunker of approximately 800 tons capacity.

Regulation of feed from the suspension bunker to primary grinding is accomplished with a Merrick Feedoweight that can be spotted under any one of 12 openings in the bottom of the bunker. A 6x12-ft Marcy rod mill charged with 3-in. rods is the primary grinding unit, discharging to a 6x28-ft Dorr Classifier. The secondary grinding unit is a 9-6-8 Hardinge tricone ball mill charged with 1½-in. balls, operating in closed circuit with the same classifier.

The pulp from the classifier is conditioned in two 6x7-ft Wemco conditioners before flotation. Roughing and scavenging in Galigher No. 48 Agitair cells produces the final tailing. Reagents in use are: copper sulfate as activator, Aerofloat 211 as promoter, and Dowfroth 250 as frother. Rougher concentrates are cleaned in Denver No. 21 Sub-A flotation machines. Cleaner tailings are joined with the scavenger concentrates and returned to the circuit through a 6-in. Dorrclone. Underflow from the hydrocyclone is returned to the ball mill, and the overflow goes to the feed conditioners.

Final concentrates are thickened in a 30-ft Dorr thickener. From the thickener they are pumped to a 5-disk, 6-ft diam Eimco Agidisc filter by a No. 2 B Dorr-Oliver O.D.S. pump. The filter cake is fed into a 5x30-ft Hardinge Ruggles-Coles oil-fired dryer. The dried concentrates are loaded into boxcars with a Hough Payloader.

Another zinc flotation mill of the **New Jersey Zinc Co.** is now under construction at Treadway, Tenn., to serve the Flat Gap mine. This ore is sphalerite in dolomite, similar to the American Zinc and U. S. Steel ores in that district. Essentially the same equipment and flow sheet will be used as at Jefferson City, except that at Flat Gap there will be two units for a design capacity of approximately 2000 tpd. This mill is scheduled for completion the third quarter of 1957.

The **Tri-State Zinc Co.** is opening a mine and building a 700-tpd flotation mill on a similar ore at Timberville, Va., about 25 miles north of Flat Gap.

The **American Zinc Co.** at Mascot, Tenn., is actively testing mechanical flotation machines and considering a new mill nearer their ore reserves. In recent years American Zinc has discovered higher-grade zinc deposits 20 to 25 miles northeast of Mascot.

Acceleration of zinc mining activity in Tennessee, exemplified by the foregoing items, gives support to the idea that Tennessee may be a leading producer in a very short time.

Emperius Mining Co. at Creede, Colo., is rebuilding its silver-lead-zinc mill for 250 tpd.

Of considerable interest is the fact that **Bunker Hill,** at Kellogg, Idaho, has suspended operation of its sink-float section on the basis that flotation of the whole ore, particularly at present lead and zinc prices, is more profitable. Bunker Hill used the Huntington-Heberlein process with galena as medium.

CANADA: Consolidated Sudbury Basin Mines, Ont., is proceeding with its new 3000-ton mill, production planned for summer of 1957. The first stage of the program is the concentrator to produce copper, lead, and zinc concentrates, and pyrite for later acid manufacture. The new mill is 12 miles west of Sudbury.

Transcontinental Resources has reopened the Hewitt and the Slocan Van Roi mines at Sandon, B. C., and are milling a nominal tonnage pending development of the lower levels of this silver-lead-zinc property.

Cronin Babine at Smithers, B. C., have resumed operations at the Babine Bonanza mine. The **Sunshine Lardeau** mine, a lead-zinc property to the north of Kootenay Lake, is now milling at a rate of 100 tpd.

The Bluebell operation of the **Consolidated Mining & Smelting Co.** is now treating gravity plant tailings from the original operations which extended from 1900

to 1927. These tailings are mainly zinc (marmatite) and were deposited in the lake under 70 to 400 ft of water.

Silback Premier Mines in the Portland Canal area has resumed operations and is now milling at 300 tpd. This is a lead, zinc, silver operation.

In New Brunswick, **Heath Steele Mines Ltd.** has a 1500-ton mill under construction and production is expected to begin in 1957. The ore is a complex copper-lead-zinc ore.

Brunswick Mining & Smelting Corp. Ltd. is still carrying out pilot plant tests on its very complex copper-lead-zinc ore. Results obtained so far are satisfactory, but it is felt that better results should be obtained before the final plans of a large mill are made.

Keymet Mines Ltd. shut down its lead-zinc-silver mill early in 1956.

MEXICO: Developments in Mexico during 1956 reached a new low. **Canamex's** new 425-tpd Au-Ag-Pb mill at La Mojina, north of Chihuahua City, was reported in operation late in the year. **Silviano Perez** started a 150-ton Pb-Zn mill at Gualterio, Zacatecas, in June. British Columbia interests have completed a 150-ton Ag-Pb mill on the old **Fortuna American** property near Casas Grandes, Chihuahua.

PERU: Banco Minero recently completed a 100-ton Pb-Zn-Cu flotation mill, later to be enlarged to 300 tpd, in the Tonsuyoc district. **Mauricio Hochschild** is completing the first half of its new 200-tpd silver-lead-zinc concentrator at Condoroma, southern Peru. The new 200-ton Pb-Zn flotation plant of the **Sindicato Minero Rio Pallanga,** being built at Alpamarca, started up late in the year.

Changes in the flow sheet are being made in the **Minas de Cercapuquio** Pb-Zn flotation mill. A sink-float section is being added, and production will soon reach 350 tpd. Capacity of the **Huamachuco** Pb-Zn mill has been increased to 250 tpd.

Sacracancha-Galera will build a 70-ton Pb-Zn mill in the Morochocha district. The second 400-ton unit of the new 1200-ton flotation concentrator of the **Compania Minera Atecha** is in operation.

AFRICA: In Morocco, **Societe des Mines de Zellidja** is going on with the flotation of oxidized zinc in the tailings from the 3000-ton lead-zinc mill. From heads running 3 pct zinc, a 25 pct concentrate is obtained with a recovery of 75 to 80 pct. This operation was begun in 1954 and more than 100,000 tons of concentrate have been accumulated so far. A Waelz kiln plant is being put in operation to treat the concentrates at the rate of 300 tpd.

Miscellaneous Commodities

MERCURY: The new 100-tpd mercury flotation mill of the **Mina La Marina** at Huitzuco, Guerrero, Mexico, went into operation early in the year. **The Nevada Mercury Corp.** completed a modern 100-tpd flotation concentrator in early summer. This plant, 16 miles southeast of Lovelock, is the first flotation mill in Nevada for mercury ores.

NICKEL: The 250-ton flotation mill of **North Rankin Nickel Mines** on the west shore of Hudson Bay will go into production early in 1957. The ore runs 3.3 pct nickel, 0.81 pct copper, and carries some platinum. **New Manitoba Gold Mines** is planning an 800-tpd flotation mill at Cat Lake for copper-nickel ore. A bulk flotation concentrate will be separated by flotation.

Preliminary construction has started on a new $12.5 million concentrator for **International Nickel Co. of Canada** on a site adjacent to the company's Levack mine, five miles west of Sudbury. The new mill will go into operation in 1958 at a rated capacity of 6000 tpd and will produce both nickel and copper concentrates. The nickel concentrate will go to International Nickel's Coniston smelter and the Copper concentrate will be treated at the Copper Cliff reduction plant.

Nickel Rim, in the Sudbury district, plans an increase in mill capacity from 700 to 1000 tpd by the end of 1956 and to 1500 by summer 1957. Ore reserves are reported at 0.74 pct nickel and 0.32 pct copper.

ASBESTOS: The **Cassiar Asbestos Corp.** in British Columbia is increasing milling rate to 750 tpd. American Smelting & Refining Co.'s new 5000-tpd asbestos milling plant at Black Lake, the **Lake Asbestos Co. of Quebec Ltd.,** is making steady progress towards completion about June 1958. Rod milling and ball milling were tried in pilot plant runs, but conventional impact mills developed in the asbestos industry produced a higher utility value and were therefore adopted.

PHOSPHATE: A discovery made a few years ago and brought to light this year is a very large low-grade phosphate deposit off the west coast of Baja California. This deposit may be marginal in today's market, but it can be considered one of the largest potential sources of phosphate for the future. The property is largely controlled by Mexican interests, incorporated as **Mina Fornos S.A.**

FLUORSPAR: Reynolds Metal Co. reportedly is building a 300-ton acid grade fluorspar mill at Eagle Pass, Texas, to treat ores from Mexican Mines in Coahuila and San Luis Potosi. The **A. Romo** interests operating fluorspar mines and mills at Muzquiz, Coahuila, Mexico, increased the mill capacity from 200 to 400 tpd.

The **General Chemical Corp.'s** 100-ton mill in Deming, N. M., built in 1933, closed down after many years of continuous operation.

MISCELLANEOUS: International Minerals & Chemical Corp. has installed a mica reclaiming plant near Greenville, Tennessee, to recover mica from a TVA lake.

Several new small mills active in the Spruce Pine area of North Carolina to recover feldspar, mica, and rare earths.

The Carolina Pyrophyllite Co. is constructing a mill in Granville County, near Stem, N. C., to produce pyrophyllite for the ceramics industry. The beneficiation plant will contain a roaster to make the iron amenable to magnetic separation.

Industrial Minerals Co. at Kings Creek, S. C., is building a barite flotation mill. It will employ a vibrating ball mill.

Magnet Cove Barium Corp.'s new barium mill went into operation at Battle Mountain, Nev., early in the year, with capacity of 175 to 200 tpd.

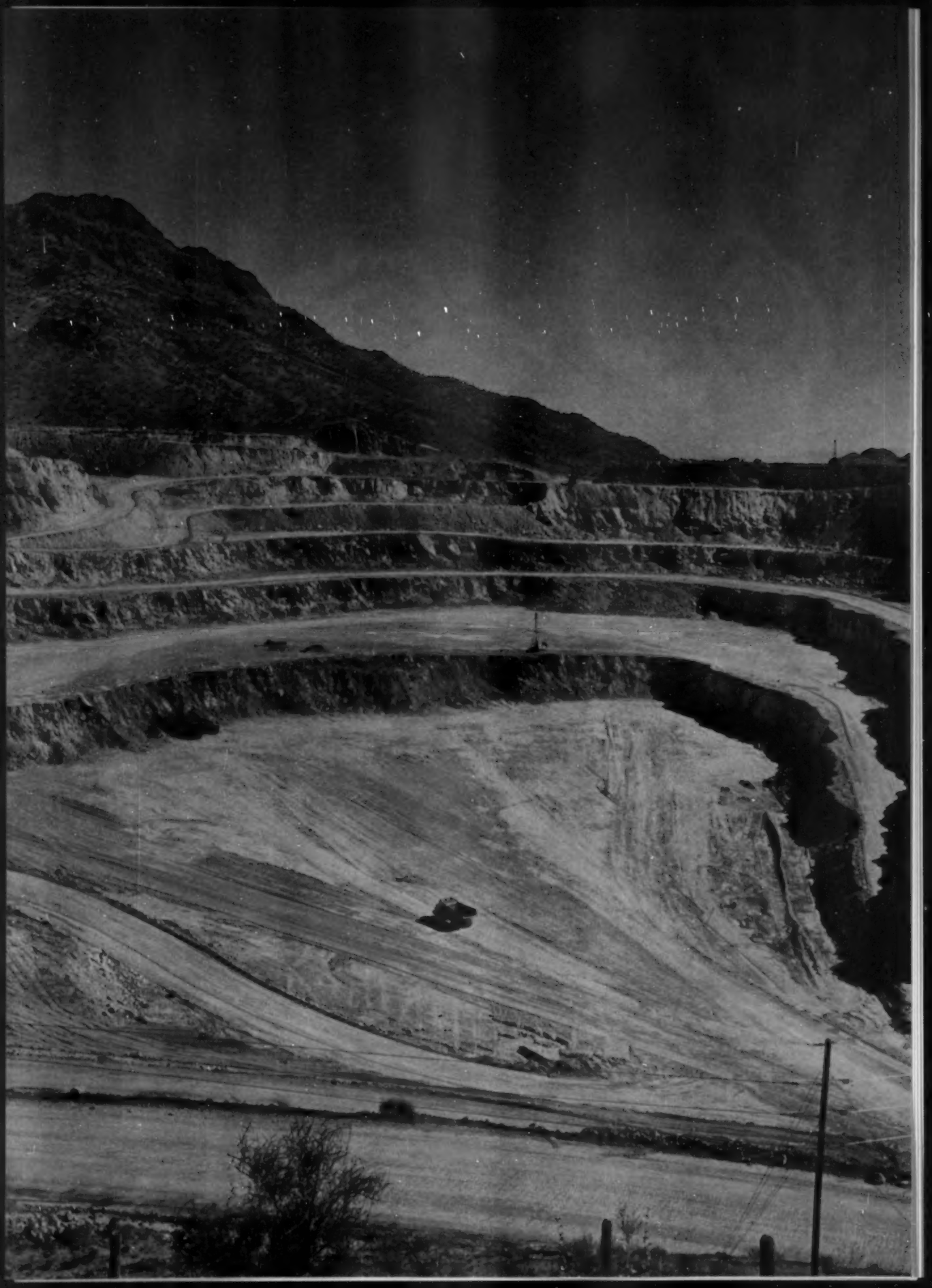
Quebec Lithium Corp., Canada's first producer of lithia concentrates, is approaching full capacity rate of 1000 tpd.

The increasing use of titanium as a strategic metal has led to wide interest in rutile, main source of the metal. Australia's sandy beaches were of special importance in 1956. At Dunwick, North Stradbroke Island, a new separation plant will produce 12,000 tons rutile annually, operated by **Titanium & Zirconium Industries Pty. Ltd.** A new dredge supplies 110 Humphreys spirals, from which the heavy mineral is then separated and graded by high tension, roll-magnetic, and electrostatic equipment following the Florida practice.

In Ceylon the government will develop large ilmenite bearing deposits on the northeast coast.

Acknowledgment

Of 34 persons asked to serve as regional and commodity reporters, 32 contributed. In addition to these there were many volunteers. We especially acknowledge the notes on uranium contributed by E. H. Crabtree and B. S. Crocker; notes on Germany by Professor A. Goette of Aachen; on Sweden by Professor Per Kihlstedt of Stockholm; on France and North Africa by Professor Maurice Rey of Paris; on South America by Carl Westphal and his correspondents; on South Africa by Max Goldick. Help from A. C. Richardson, R. H. Lowe, F. M. Lewis, George Sewell, L. J. Erck and many others is also gratefully acknowledged.



Open Pit Mining

The Eastern United States

Edited and Compiled by John G. Hall,
Plant Manager, Titanium Div., National Lead Co., Tahawus, N. Y.

MANY millions of tons of raw materials are removed each year from open pit mines in the eastern U. S. These materials are used by industry to produce aluminum, asbestos, barite products, building stone, cement, crushed stone, copper, coal, dolomite, garnet, iron, limestone, mica, phosphate, phyrophyllite, titanium products, and wollastonite. Improvements in open pit mining techniques through the years have made open pit mining more and more attractive as compared to underground methods. Today ore deposits that formerly would have been mined underground have proven to yield more profit if mined by open pit methods.

Ever-rising labor and material costs have made equipment capable of high-volume production and low-unit cost—and supplies rendering low-unit costs—not only attractive to open pit operations, but essential to their economic existence. During the past year, the major advances have been in drilling and blasting operations, and the application of large capacity materials handling equipment. Mining men from the Great Lakes, Northeast, East Central, and Southeastern regions of our country tell in the following articles of the trends in open pit mining in their areas during 1956.

Trends and New Developments in Minnesota Mines

by John Chisholm, General Supt.,
Oliver Mining Co., Hibbing, Minn.

Importation of high quality iron ore from foreign sources in constantly increasing quantities in 1956, plus the accomplishment of producing high-grade taconite and jasper concentrates in volume during the same year, induced Lake Superior iron ore producers to look closely at their beneficiating and mining practices.

Improving Quality of Lake Superior Open Pit Iron Ore: With the increased volume of higher quality iron ores coming into the United States market, a demand for better quality ores from Minnesota open pit mines was expressed immediately. The primary effect of this demand for ores containing less silica and more iron units was to direct attention to an improvement in beneficiating methods. However, the demand for higher quality material was also felt in the mines where greater selectivity of iron ores suitable for treatment by one or more methods of beneficiating was strongly emphasized. Lowering the average silica content and raising the iron content became one of the primary objectives of most iron ore producing companies in the Lake Superior Ore District. Excluding the development of taconite, which continues to receive major attention from large iron ore producers, this effort to improve the quality of all iron ore shipped from this mining district became the most significant general trend of the year.

Blasting with Ammonium Nitrate (Fertilizer Grade): In actual mining processes one of the more novel developments is the use of fertilizer grade ammonium nitrate as a blasting agent in place of other explosives commonly used in most Minnesota open pit mines. Furnished in bags in pelletized form, the size of 3/32-in. shot or a trifle smaller, this material when mixed with ordinary fuel oil in known proportion and detonated by conventional blasting methods produces very satisfactory results from a blasting standpoint.

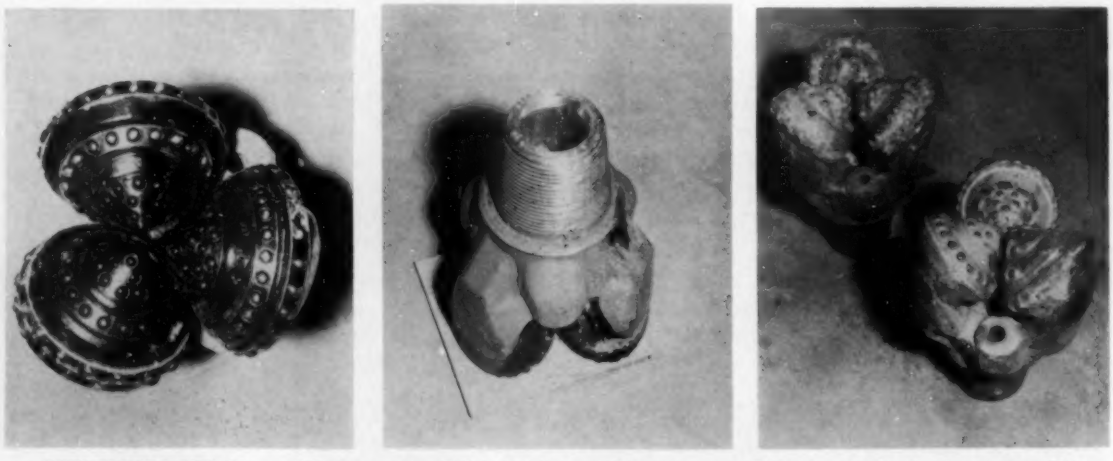
There are some disadvantages. It is extremely soluble in water and, therefore, must be protected from the elements and cannot be used in wet holes. Its effectiveness in the harder rock and taconite has yet to be determined. However, for a large proportion of the material in most Minnesota open pit mines requiring some blasting, it does a most creditable job.

From an economic standpoint, the cost is approximately one-half of normal explosive cost per ton of material broken. Whether some disadvantage not now apparent will become evident with continued use remains to be seen.

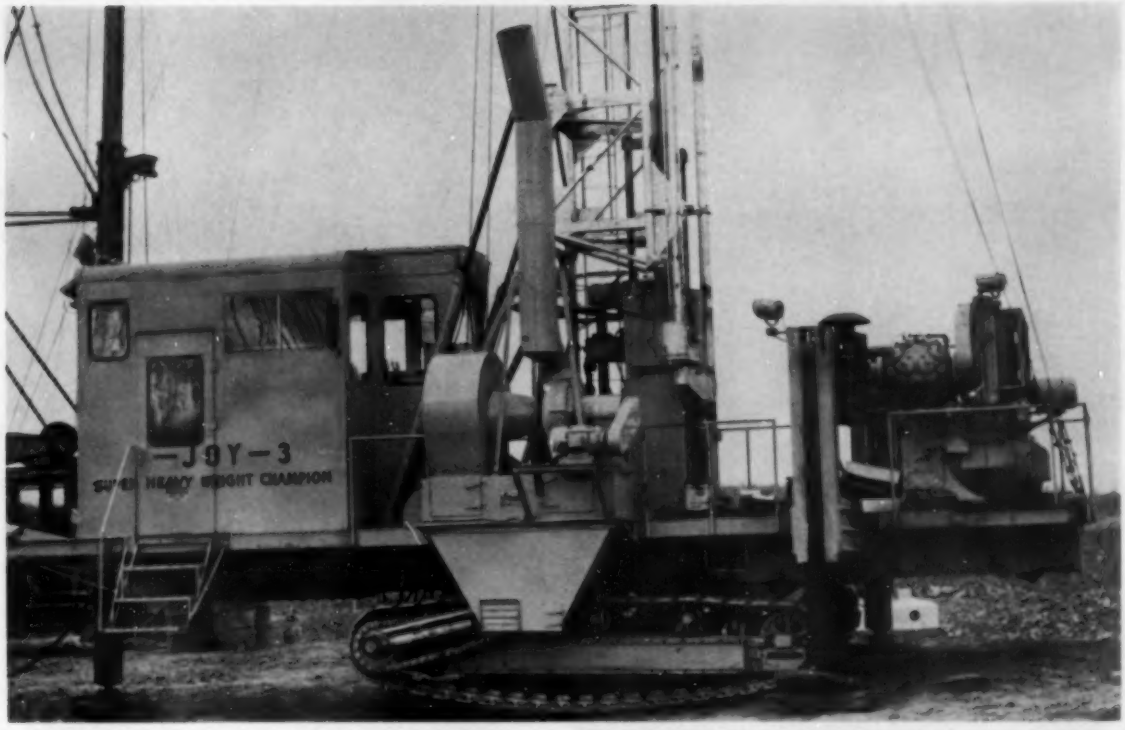
Rotary Blast Hole Drilling: Rotary blast hole drilling is another development which is presently attracting a great deal of attention from the open pit iron mining industry. Developed for strip coal mines and limestone quarries in the North Central area of the U. S., these large drilling machines are performing satisfactorily in a number of open pit iron ore mines in the Lake Superior area. It is estimated that one such drill will replace several of the conventional blast hole drills currently in common use in the District.

Bit life is a major problem with this type of drill. Its final success will depend largely on development of bits which will stand up satisfactorily under the varied drilling conditions encountered in this region. Rotary drill bit manufacturers are acutely aware of the problem and are conducting extensive tests to develop a product which will stand the severe drilling conditions to which such bits will be subjected.

Heavy Duty Truck Haulage Tires: Well over 50 pct of the iron ore produced from open pit mines in the Lake Superior District, plus the removal of rock and surface stripping connected therewith, is transported in heavy duty haulage trucks.



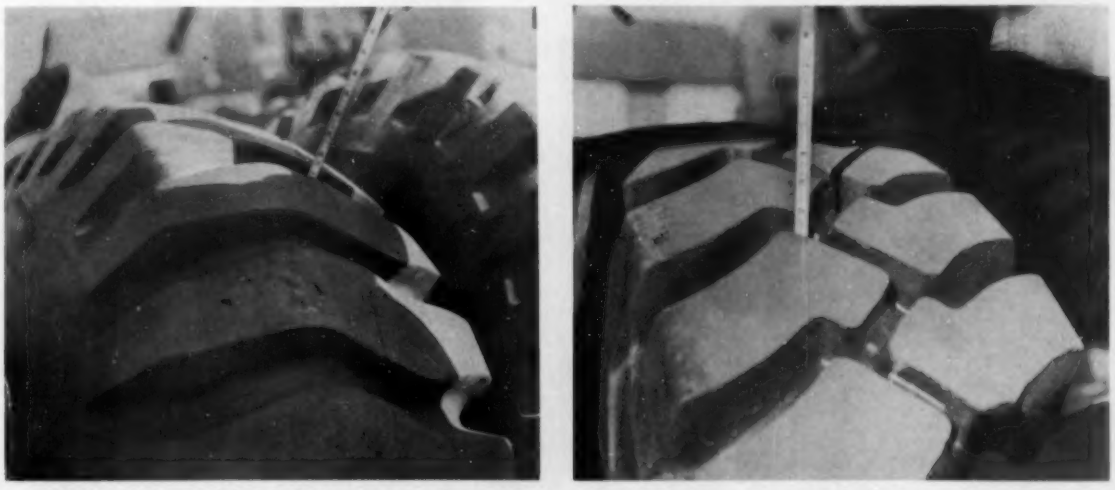
ROTARY DRILL BITS: New carbide insert rotary drill bit is shown at left and center. Right view shows worn insert rotary bit after drilling approximately 850 ft in medium hard taconite.



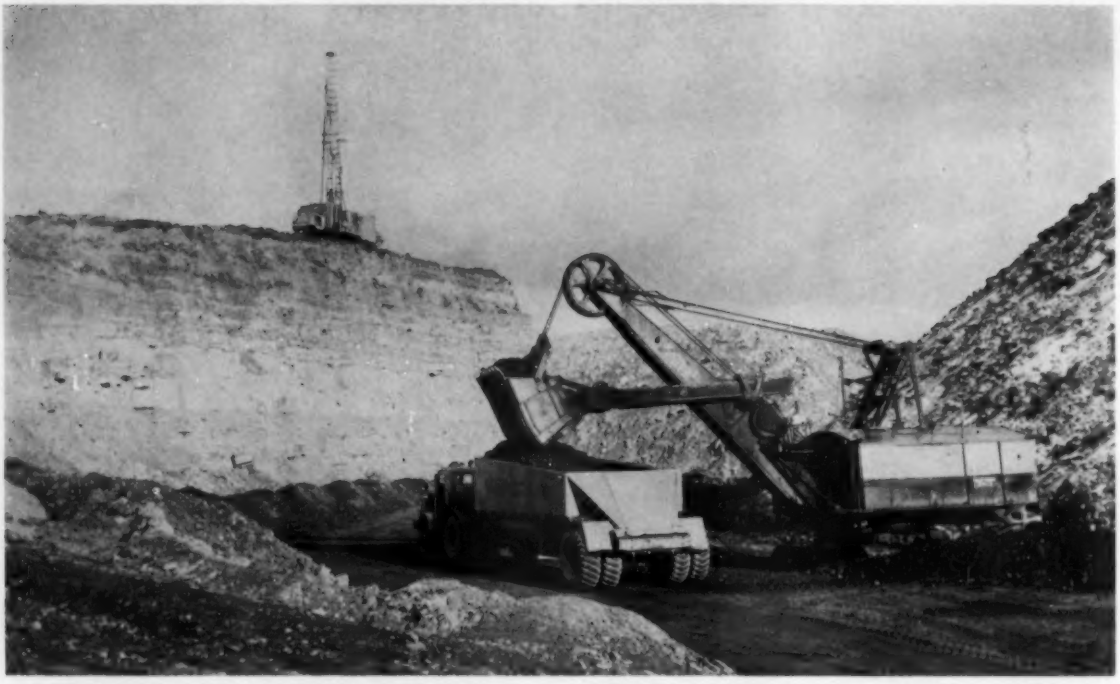
ROTARY DRILLS: Proved successful in many open pit operations, rotary type drill is replacing more and more older type machines. Joy Champion is shown.

Tire life under year-round service has always been one of the major cost items for this method of transportation. For the past year or more, at least one of the major tire companies has had experimental trial tires in service in this area which were manufactured having perhaps 50 pct more tread rubber than had formerly been used on the best heavy duty tires produced to date. These tires are giving a tire life almost double the base 2500-hr period upon which standard heavy duty truck tires are adjusted in price. One trial set of these tires with one recapping has operated more than 6000 hr in one producer's experience. Additional experience with such tires is necessary before the industry will accept them generally. Favorable comments on performance to date have been received from numerous sources.

The four items mentioned above constitute the major trends and developments in open pit iron mining in the Lake Superior District during 1956.



HEAVY DUTY TRUCK TIRES: Ordinary new 24 ply truck tire is shown at left, note tread depth. The 36 ply experimental heavy duty tire (right) has ½ in. deeper tread. More rubber on tread and additional plys may lower tire costs.



COAL STRIPPING: Modern rotary drill—large capacity trailer type haulage—electric shovel—represent combination capable of great flexibility and low production costs.

Open Pit Mining in the Ohio Valley Region

by J. Richard Lucas, In Charge Mining Engineering Div.,
Ohio State University, Columbus.

A predominant proportion of the total mineral production in the Ohio Valley is mined by open pit methods. Among these are numerous limestone and dolomite open pits to supply the raw materials for nearby steel mills, cement plants, and agricultural uses. Coal strip mines which are among the largest in the country provide fuel for the gigantic electric utility industry, steel plants, and many other industries in this heartland of American industry. Large quantities of gypsum, shale, and sandstone are also produced in this area to feed the raw material appetite of the construction and glass industries. All of these mineral raw materials are produced in the Ohio area by open pit mining techniques, and large tonnages of these bulk raw materials are consumed nearby because they are cheaply produced by high mechanized and efficient open pit methods.

Fortunately, most of the mineral deposits lie conveniently near the surface with sometimes little or no overburden to be removed. In the case of coal, however, much of the shallow seam coal has already been exhausted, and new supplies are available only at greater depths with correspondingly higher overburdens. Because of this condition, greater stress is being placed on development and utilization of larger equipment which will economically permit removal of this higher cover. As a result of a vigorous machinery development program, it is now feasible to remove as much as 100 ft of rock overburden for production from a 4-ft coal seam, and the future indicates that this performance will be bettered.

Operations in open pit mining are often similar to all pits, and the best approach to discussing the new developments and trends in this field is to consider each of the following pit operations individually:

Drilling: The objectives of drilling in this area are twofold: to break the overburden and, secondly, to break the uncovered ore. In coal stripping the greatest drilling effort is given to the overburden, while in the dolomite and limestone pits most of the drilling effort is toward the ore. Where considerable drilling is done, the trend during the year has been toward rotary drilling. To promote this drilling method, some of the primary problems associated with rotary have been solved by substituting air for water, by mounting large rotary drills on wide caterpillar treads, and by mounting smaller drills on heavy trucks.

Rotary drilling speeds in rock are about four to eight times greater than those experienced with churn drills. The trend is definitely toward larger diameter holes on greater spacing centers to reduce the number of feet of hole drilled overall. One manufacturer reports more than 60 pct of their recent sales of machines were for drilling holes larger than 10 in. diam. Sizes of rotary drills goes up to as high as 12¼ in. diam.

A recent interesting drill development is a rotary

drill with about a 90-ft high mast that eliminates the addition of tools for most overburden drilling. The drill stem is an auger which assists the air in clearing the cuttings from the hole. This seems to offer considerable future promise under certain difficult conditions.

Another manufacturer has developed a vertical auger drill that will complete a 9-in. hole in sandstone to 100 ft or more. Daily production of this machine is in the order of 600 ft per shift.

There has long been a need for development of a horizontal drill using a rotary bit in operations where considerable overburden has to be removed. Reduction of drill hole footage and good firm ground for a drilling base have long been regarded as a considerable advantage to this type of drilling. At least one company has developed and is continually improving a commercial model using a rotary bit for horizontal drilling. This may receive more attention in the near future from operators as they become more familiar with its performance.

Blasting: There has been a considerable amount of new development in this area during the past year or two. This was initiated by the announcement of a new low explosive development, Akremite, that has proven to be a tremendous impetus to a whole new series of low explosive developments. By far the greatest single advantage is the considerable cost reduction. This goes well with the necessity of lower drilling and shooting costs for those operators who have gone into higher overburdens to prolong the life of their mines. Many companies are marketing low explosives similar to Akremite under the names of Nitro-Carbo-Nitrate, Unamite, and Methanite. They consist of only small variations of the following ingredients:

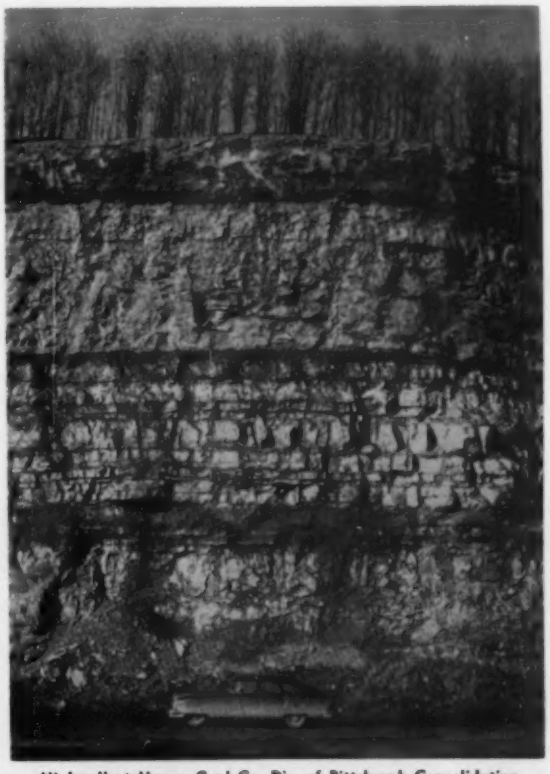
90 pct ammonium nitrate
5 pct carbonaceous material
5 pct nitro-methane.

Examples of the results expected are shown in an Ohio mine where the power ratio is about 7 cu yd per lb in over 70 ft of overburden with a 40-ft spacing. The speed of these explosives ranges from about 10,000 to 13,000 fps depending upon the mixtures.

This year has also shown a continued trend to a wider and more efficient use of Primacord type detonating fuses and MS delay blasting caps. With heavier overburden and more explosives per hole and per blast, the reduction of excessive vibrations, which result from heavy charge concentrations, have been receiving increased attention from both the operators and the public. The use of MS delays have also improved fragmentation.

Loading: The outstanding trends in this area have been toward the development of larger capacity shovels to remove high overburdens which were once impossible to attack economically with existing equipment. An example of this development is a newly built 60 cu yd shovel that can handle overburdens of over 100 ft. Even with this machine, the thought of the manufacturer and operator is to increase the bucket capacity after enough experience has been gained. Previous to this year, the largest operating shovels were around 45 cu yd, and it has been publicized that a shovel of 70 cu yd capacity is now being designed and will soon be built. Tremendous reserves are now being added and made available to mineable acreage as a result of these remarkable developments. The same trends have also manifested themselves in the development of larger and more maneuverable drag lines, but in the

Fifty-yard shovel, once top size, has been surpassed already by 60-yd model now in operation—still larger units are planned.



Highwall at Hanna Coal Co. Div. of Pittsburgh Consolidation shows overburden faced by strip mining operations. Strip-to-seam ratio continues to rise.

Ohio area most interest seems to be given to the large shovels for better overall operating results.

Haulage: In the Ohio Valley area little dependence is placed upon rail haulage and rail equipment, but considerable stress, therefore, is placed upon truck haulage and its modifications. With the construction and maintenance of adequate, well drained haul roads, truck haulage is very competitive with other types of pit haulage especially on short hauls of a few miles from a rapidly changing working face. The inherent flexibility of truck haulage is its greatest asset—it permits mining selectively and from scattered working areas without serious difficulties.

The trend in the higher production pits is towards larger truck capacities in excess of the present 50-ton maximum pay loads. In addition, many of these larger trucks are being reinforced and rebuilt to handle even greater than designed tonnages. Emphasis, as might be expected in newly developed machinery, is on reduction of high maintenance costs by implementation of preventative maintenance programs. These programs are well worth the effort in highly mechanized pits.

Operations Research: This is an area that is becoming fundamentally more important, especially in those operations where competition and high costs may threaten even the existence of many pits. It has been a long accepted and proven fact that the amount of improvements and results from this program are almost directly proportional to the effort directed towards operations research provided everything else remains equal.

Open pit mining seems a fruitful area for the implementation of such a program. The field of drilling alone offers excellent potential with primary consideration given to drill depths, drill spacing, drill machinery, and drill practice. Also the area of blasting offers excellent cost improvement possibilities with special consideration given to explosive type, explosive strength, hole loading, detonation patterns, and explosive concentration. These are just a few of the areas that would benefit from an aggressive, well directed and planned operations research program. Increasing numbers of progressive operators are introducing such programs on a trial basis while others are giving more serious consideration to them.

In this review of this year's trends and developments in the Ohio Valley Section special emphasis has been given to drilling, blasting, haulage, loading and operations research in open pit applications. Because of the competitive pressure on some of our mineral products, great strides of progress and developments have been the result in these applications.

SIZE CHAMPION—AT THE MOMENT: Largest capacity shovel in the world—60 cu yd capacity—stripping overburden from coal seam with about 100-ft highwall.

Open Pit Mining in the Lehigh Valley Region

by W. Julian Parton, Asst. to the President,
The Crushed Stone Co., Easton, Pa.

New high speed drills of various types are gradually replacing the churn drills formerly used at most of the quarry operations. Both rotary and percussion types of drills are now in use. One of the newest improvements has been the development of a percussion mechanism which follows the bit into the hole. This development has resulted in doubling the penetration rate of the piston type drill formerly manufactured. The drill hole produced by the down-the-hole unit is perfectly round and straight and facilitates charging these holes with powder. The down-the-hole attachment also makes it possible to drill holes in excess of 150 ft and, therefore, does not have the depth restriction encountered with the original piston-type drill. Because of the advantages of the down-the-hole drill, many of the piston-type drills in service at various quarries are being converted to down-the-hole drills. Another important advantage of this development is that the down-the-hole drill is now available in a truck mounted unit which makes it possible to move the drill readily from one quarry to the other. By so doing, the full advantage of the high speed drilling rig can be exploited.

Self-Propelled Drills: Another drilling development is that of self-propelled wagon drills capable of drilling up to 4½-in. diam holes. Sectional drill rod equipment has been developed in conjunction with this drill to make it possible to drill holes to depths of 50 to 75 ft. Drilling rates are high and the self-propelled feature makes it possible to move this type of drill from hole to hole with minimum difficulty. This type of high speed drilling equipment has found ready application on construction work of various kinds, particularly road construction. Quarries which have converted to the use of smaller diameter holes report that they have been able to obtain better breakage because of the improved distribution of the powder. Where fragmentation has been improved, less secondary blasting is required and loading and crusher capacity have been increased. By using the small diameter holes it is possible to minimize vibration and blasting complaints. Another advantage claimed for the use of this type of equipment is that the initial capital investment required is low.

With the development of portable high speed drilling equipment, many contractors are now willing to do drilling work on a contract basis and there appears to be an increase in the amount of contract drilling done at various quarries.

The most significant trend in blasting practice is the increased use of the new-type ammonium nitrate powders (Akremite and similar low cost powders). These ammonium nitrate powders are being used exclusively at certain quarries having dry holes and easier shooting materials. At other quarries a procedure has been worked out which makes it possible to use the low cost powders in conjunction with standard grades of dynamite or blasting agents. Sev-

DOWN-THE-HOLE: Percussion type machine is finding wide acceptance in open pits. Unit is attached directly to carbide tipped bit and follows bit down the hole. Machines are either crawler or truck mounted with power supply from diesel driven rotary type compressor to make unit independent of outside power source.

Manufacturing blasting agent at the hole by mixing fertilizer grade ammonium nitrate with 5 pct of fuel oil.

eral problems were first encountered when the new type powders were first employed which, in certain cases, resulted in unsuccessful application. These powders are less sensitive than standard grades of dynamite and the proper placement of primer cartridges must be worked out to suit the conditions. The lack of water resistance of these powders must also be taken into consideration, and, unless the powders are adequately protected by special-type packaging, use of these powders must be restricted to dry holes or to the upper part (dry portion) of wet holes. Because of the less sensitive nature of this type powder, it was originally thought that it could be used only in larger diameter holes. However, recent developments have shown that it can be used in smaller diameter holes by using it in conjunction with standard grades of dynamite and by the proper placement of primer cartridges. Packaging of these new-type ammonium nitrate powders is still in the state of change since attempts are still being made to make the cartridges as water resistant as possible.

Blasting agents have also been developed which are less sensitive than standard grades of dynamite and, accordingly, can be shipped at lower freight rates. Also, less stringent restrictions are imposed on the use of these blasting agents. Substantial savings are being obtained by operators who use these low cost powders properly. Little or no difficulty in fragmentation is reported by these operators.

The only change noted in quarry transportation methods is the use of truck and trailer combinations where side dump truck or pans have been in use. By the use of the tandem units, operators have doubled the pay load capacity of their hauling units simply by adding a trailer pan behind the truck mounted pan. Doubling the capacity of the hauling units by the above procedure can be done very advantageously at certain quarries where bin or feeder capacities are restricted, requiring the dumping of a small tonnage at one time. The general trend of increasing the capacity of hauling equipment is continuing where these larger capacity units can be used advantageously. Hauling units carrying loads up to 50 tons are now being used in certain cases.

Tandem type heavy duty haulage unit offers increased capacity.

New Developments in the Southeast

Open Pit Mining

by R. C. Crumbaugh, Southeastern Manager,
E. I. duPont Explosives Div., Birmingham

There are numerous open pit mining operations in the Southeast—on both metallic and nonmetallic ores. However, the coal stripping operations are the ones that have shown the greatest advancement. Actually, the whole coal industry in the South has been kept alive primarily due to the developments that have made possible the mining of thin seams of coal with heavy overburdens on an economic basis competitive with that more easily mined in other fields.

For years, the rule of thumb for removal of overburden in coal stripping was 1 ft per 1 in. of coal. As a result of developments during the last few years, it is now feasible to remove an average of 2 ft (and sometimes more, depending on the grade of coal) per 1 in. of coal uncovered. There are three factors responsible for this:

1) Improved drilling equipment makes it possible to drill large diameter holes at speeds even greater than the drilling of small diameter holes in the past.

2) As a result of large diameter drilling, it is possible to utilize low velocity, less expensive explosives that develop their full efficiency only in large diameter holes.

3) To keep pace with the drilling and explosives developments, large and efficient draglines and shovels have been introduced in open pit mining.

It is not uncommon for the larger stripping operations to drill holes up to 9-in. diam and blast overburdens up to 70 ft to recover high grade coal of only 20 to 30-in. thickness. Removal of overburden is made possible only by use of large shovels (up to 30 yd) and large draglines (up to 20 yd) in conjunction with improved drills and explosives developed for this particular type of mining.

Large heavy duty trailer haulage units are in wide coal use.

Liquid oxygen explosive (LOX) being unloaded from truck.

In most stripping operations, where the open pit mining is used, the overburden is cast on spoil banks without the use of hauling equipment. However, in some operations, where the most expensive shovels and draglines cannot be justified, modern hauling equipment has been introduced to take some of the burden from the digging equipment. In those instances, bulldozers and pans have been used by small operations very effectively.

Summarizing: the coal industry in the South has not only been kept alive but coal tonnage is actually greater in certain areas as a result of new developments in equipment and technique which are now used in open pit mining.

Lower blasting costs with effective breakage has created wide acceptance for low cost, safe, and easily handled nitrogen family blasting agents.

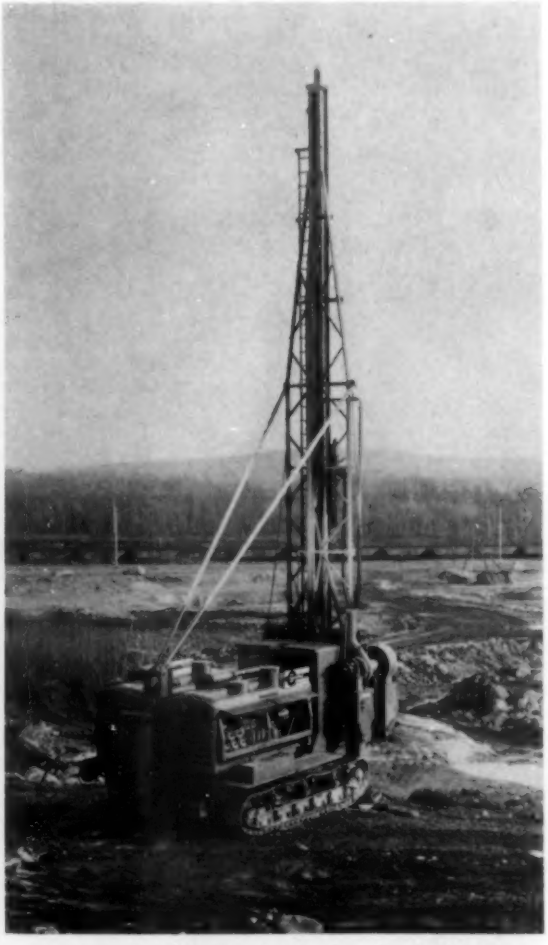
Stone Quarries

by Nelson Severinghaus, Vice President,
Consolidated Quarries Corp., Decatur, Ga.

Within the past year there have been two medium sized plants built in Georgia. These crushing and screening plants are designed with centrally located control towers for a minimum of operating labor. They represent a long step forward towards automation of crushed stone plants.

In areas where suitable rock is available close to large sized road projects, portable plants designed especially for successful use in abrasive rocks have been furnishing increasing tonnages.

Much of the aggregate of the Southwest comes from granites and gneisses. In these quarries practically all of the drilling is now being done with percussion drills and carbide bits of 4½ in. diam or less. This has resulted in better fragmentation with blasting and reduced overall costs as compared with large diameter holes.



Quarrymaster drill is one of group that offer flexibility for various size holes, and this particular unit can be converted to down-the-hole operation.

Trends in Iron Mining—Northeastern Region

by F. J. West, Foreman—Mining and Stripping,
Jones & Laughlin Steel Corp., Star Lake, N. Y.

Jones & Laughlin Steel Corp.'s Benson Mines pit is approximately 2 miles long and 700 to 1400 ft wide. Working faces are 50 ft high. There are two types of ore, magnetite and martite. The magnetite ore is a much better breaking ore than the martite, which is somewhat friable and tends to come out in large blocks.

Most of the primary drilling to date has been done with Bucyrus Erie 42T churn drills, using a 9¼-in. hole on a pattern of 20-ft burden on the toe and 24-ft spacing. Average footage per churn drill shift is 33 ft, and average footage per bit sharpening is 10½ ft. Production per churn drill shift is 1285 drilled tons.

A Joy 60BH Super Heavyweight Champion rotary drill is now under test. For 6300 ft of drilling the average shift has been 114.7 ft and bit life using Hughes Tricone W7R Aerobits has been 589 ft.

The 60BH drills a 9⅞-in. hole which allows the powder load of 9-in. cans to be supplemented with Pelletol. This has allowed an increase in the drilling pattern to 24x30 ft in the better breaking magnetite ore with little appreciable change in the size of the broken ore. On this pattern, production per rotary drill shift is 6700 drilled tons. In the martite ore the drill pattern used is 20x24 ft. Fragmentation is poor although no worse than the churn drills provided.

The Champion is a cumbersome machine. The mast is 58 ft high which makes it rather top heavy. It appears that it will not be of too much use on the rough topography of first cuts where to date the mast has cracked three times while moving. Removing the top 16-ft section of the mast may alleviate this situation. This would leave only a 42-ft mast which would cut down on the top-heaviness. With a 25-ft and a 10-ft steel together as the stem and a 30-ft rod in the side rack it will be possible to drill holes to as great as 60-ft depth with only one steel change.

Also under test is a Gardner-Denver DH143 percussion drill. It is an airtrac machine running off a 900-cfm rotary compressor. It will drill up to a 5 in. hole on any desired angle.

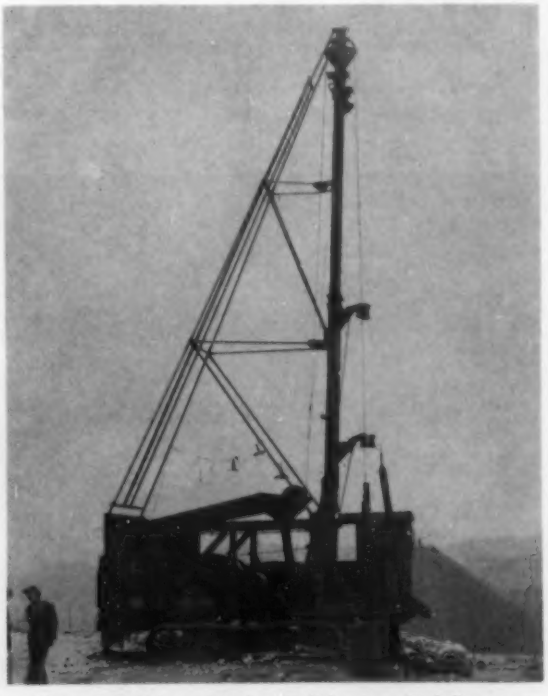
To date it has been used chiefly in an old area of the Pit along the side. The burden in this area was excessive for churn drills so angle holes were drilled on a pattern of 25-ft burden and 10-ft spacing. The resulting shot gave good fragmentation and an excellent face. Unfortunately the area was badly fractured and sand seams and broken up areas of 2 to 3-ft thickness were often encountered. This led to repeated caving of the holes from the under side which considerably slowed drilling progress. Footage per shift was rather poor here but what little experience this drill had on production faces indicates a potential of 160 to 170 ft per shift. A pattern of 16x18 ft has been found to work quite well, giving this drill a probable production of 3925 drilled tons per shift. The better powder distribution afforded by small holes raised the loading factor to 3.5 tons per lb from the 2.4 tons per lb used on churn drill and rotary drill shots.

Rifling of the bit has been a problem and is partially responsible for the poor bit life, which is 350 ft. An X-bit is under test which we hope will eliminate this.

A Joy Challenger percussion drill mounted on a tractor has also been in use to trim permanent benches and fill in as a production drill. The Challenger was originally run off a 600-cfm piston compressor but this air supply was not adequate and a 900-cfm rotary compressor is now in use. The 4-in. holes are drilled on a 13x15-ft pattern. Footage per shift is 160 to 170 ft and bit life averages 670 ft. Production per shift is 2550 drilled tons. The Challenger does a very good job of bench trimming, leaving a straighter and cleaner face than churn drills, while outproducing them 2 to 1.

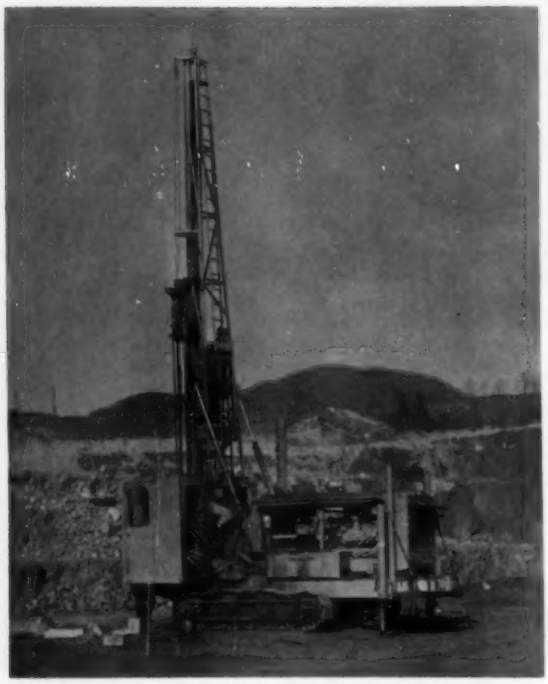
The rotary drill appears to be a definite success, especially in the better breaking magnetic ore, where it out-produces churn drills 4 or 5 to 1 while giving satisfactory fragmentation.

The Gardner-Denver has proved its worth as a clean-up drill. On production faces it also will outproduce a churn drill by 3 to 1, while giving much better fragmentation, especially in the blocky martite ore. Its one great disadvantage is the lack of shelter for the men during the winter season.



Churn drills, long a typical part of the open pit skyline, are rapidly being replaced by rotary and percussion drills utilizing large volumes of air to sweep cuttings from the hole.

Trends in Open Pit



Down-the-hole drills, rotaries, and specialized percussion drills of various types play larger role in open pit blasting.

OVER the past decade the truck haul pit has provided economy and flexibility and the means for low cost expansion of open pit production of minerals. Without flexibility and economy to make smaller pit operations possible, offered by the combination of shovels and trucks, one can question where and at what cost certain minerals would have been produced.

Drilling: Following an earlier shift to larger and larger blast holes, a second trend is now in progress: to use of smaller, faster hitting drills, used for smaller size holes. Problems here relate to relative economics of more holes to place the same amount of explosives vs fewer big holes. Answers depend on size of overall operation in some pits, and on degree of mining selectivity in others. No clear advantage shows up as yet—but the operator today has available a far greater assortment of tools than he did a decade ago. It is his job to pick the best ones.

Blasting: Drilling and blasting go hand in hand—with smaller holes one must have better loading or different explosives. In the past two years, high interest has developed in less costly nitrogen family explosives. Labels for these explosives vary: do-it-yourself, fertilizer-type, low-cost—but terms are more appreciative than critical. Anything that saves money is popular. These explosives are not the universal answer, in fact some critics do not see advan-

Still the workhorse of the industry, the churn drill is meeting steep competition from newer types. Rock hardness and character is often determining factor in drill suitability. Another factor is optimum blast hole diameter—dependent upon the required charge to be carried.

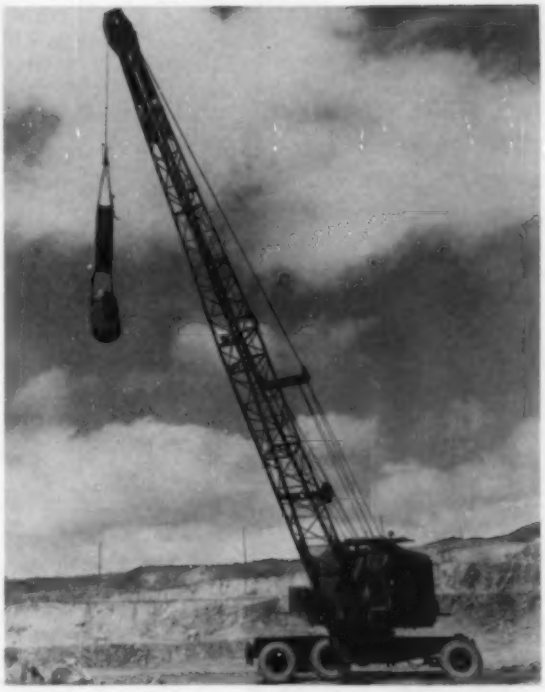
Equipment Design

tages except in special instances. Wet holes may be a problem—opinions differ as to explosive power available—loading may be better or worse than earlier materials. In any event here is another cost cutting device available to some operators.

Loading: Here the story is usually larger and faster swinging machines. Changes as yet are not dramatic. One basic change in loading technique may be initiated in the coming year. Shovels *look* much as they have. But, operators are usually swinging a bigger bucket, and often on a newer machine whose improvements are out of sight.

Haulage: Conveyor belts proved the answer on a few long stability or large tonnage jobs—usually reliance is on ever larger size trucks. Problems of tire wear are being met by tread redesign, but better housekeeping, especially as to road surface, is still best insurance against excessive rubber bills. Maintenance is getting close attention, and truck transmissions of the automatic type are as much a fixture as they are in passenger cars.

Auxiliary Equipment: Better utilization of high capital cost equipment is goal of operators who provide plenty of auxiliary cleanup and loading units. Front-end loaders, graders, pusher tractors, and fleets of small vehicles for communication and service all find a role in keeping big shovels and big trucks moving with full payload as many hours a day as possible.



Drop-ball crane is carrying the secondary breakage load at several pits. Idea started with quarry operators.

One trend still holds for loading and haulage—bigger and bigger. The 15 to 35-ton range is still the most standard for trucks, but recent sales have tended to be at top end of size range rather than in smaller units. Still larger trucks, 50 or 60-ton capacity, are becoming more common. Shovels and draglines continue to grow and grow.

COAL

A Review of Changing Market Patterns for Solid Fuels

by George A. Lamb

AMONG the main interesting developments in the coal market have been the changes that have taken place between the consumer groups. Important signs of these changes began to appear many years ago, but in a modest way, and were apparent only to the few fuel experts making broad statistical determinations. It is doubtful, however, that any of these experts appreciated the significance of their early findings, and perhaps none had the imagination to consider how extensive these changes might be eventually with respect to solid fuels sales and distribution. (Reference here will be principally to bituminous coal.)

Railroad Fuel

Major changes in coal use did become pronounced after World War II, and it did not take an expert to see what was taking place and how serious the impact was likely to be. First, was the case of the steam and diesel locomotives. The railroads had been considered the best coal customers; they were steady and large purchasers and usually paid a better price than most others. Railroad fuel provided the basic mine realization and it often was the source for operating cash during general market slumps. It was the outlet for 20 pct of the bituminous coal production, as much as 110 million tons in 1946.

The diesel locomotive was having its trial runs about the time the 1929 depression appeared. It was introduced gradually but began to demonstrate its potential by the end of the 1930's when 639 diesel units were in service, the great majority of which were switchers. Yet, this number seemed insignificant compared to the 40,000 steamers in operation, and the railroad men still considered the diesel as an experiment with a limited potential. This comforted the coal operator who also was fortified by his thinking that the railroads could not afford to hurt the mining industry, the source of their major traffic.

Whatever the belief in the late thirties, the diesel locomotive came in with a rush once World War II restraining effects upon civilian activities were dis-

sipated. Within ten years, the diesel had supplanted the steamer—and displaced a 100-million ton coal market in the process. It was a revolutionary change in fuel use—the most rapid one of magnitude that has taken place.

Coal for Heating Declines

Where railroad fuel provided the basic mine realization, it was the coal sized for the retail market that offered prospects for a profit. The retailers bought about as much tonnage as the railroads for a number of years through World War II. They were willing to pay a premium on a prepared coal that would prove attractive to the householder and other space heaters. The retail market was seasonal and it fluctuated annually depending upon weather and business conditions, but it always provided the opportunity to sell part of the production above the cost of mining.

Oil and gas crept into the heating and steam markets at first more by necessity than design and without causing much alarm. Requirements for gasoline mounted steadily and its refining resulted in additional products including heavy and light oils that needed a market. Motor vehicle registration totalled 1 million for the first time in 1913, just prior to World War I, but reached 6 million in 1918, and 27 million in 1929, and was to increase further although more gradually. Following the motor vehicle were rapid developments in the aircraft and other gasoline mechanisms. Gasoline consumption increased five times between 1918 and 1929, and then took on a slower but constant growth. Part of the refinery output—kerosene and certain light oils—coming with the gasoline production, had a ready outlet for use in cookers, room heaters, and miscellaneous purposes, but it was a limited market. Volume sales of light heating oils were needed and these were promoted through the development of the automatic oil burners for central home heating. These burners numbered only 12,500 in 1921, but increased to 424,000 in 1929 and to over 2 million by World War II. They total 8 million today. Along with the domestic units were developments in commercial and industrial burners for burning both light and heavy oils. In 1955, 340 million barrels of light oil and 79 million barrels of heavy oil were sold for heating, 83 pct in fuel markets where coal competes.

Increased drilling for crude to satisfy refining needs resulted in great discoveries of natural gas. The gas was largely wasted at the wells until the long-distance pipeline was developed, and then it was made available country-wide. Marketed production of natural gas has expanded every year since it has been of consequence, and it more than doubled between 1946 and 1955, being 9.3 trillion c.f. in the latter year. One-third of the natural gas is sold in coal markets, the larger part used for domestic and commercial purposes. In the past, off-peak or dump gas sold at relatively low prices has been a disturbing factor in the industrial fuel market both by displacing competitors seasonally and disrupting their prices generally. The adverse effects of dump gas have lessened, remaining in a few areas, because: a) gas now costs more to produce and distribute, promoting storage of off-peak loads so that sales of this fuel can be confined more to the higher priced outlets; and b) the higher priced outlets can take all the gas moved by a pipeline once that pipeline has been in an area for a period of time.

Growth of oil and natural gas in the heating market has hit hard at both anthracite and bituminous coal. Anthracite, mainly a heating fuel, sold only 24 million tons in the United States in 1955, compared to 54 million tons in 1946. Bituminous deliveries to retailers were 54 million tons in 1955, slightly over half of the 1946 figure of 101 million tons. Thus, in the 1946 to 1955 period, coal not only was unable to gain sales in a growing heating market but lost heavily among the retail customers it had served.

What about coal's loss as a heating as well as a railroad fuel? There are several answers as to which economic progress is as good as any. Heating customers wanted conveniences and they had the money to pay for them. Technological advances provided automatic furnaces and oils and gas were the fuels wanted and they could be supplied in abundance. In the same sense, the railroads were impressed by the economies attributed to the diesel and believed it to their advantage to replace their motive power with an oil burning locomotive, although a huge investment was required.

Electric Utilities Grow

Coal since 1946 is on the plus side if you take the remaining major use groups. Tonnage for the steel and coke industries tends to increase although at a gradual rate. Coal requirements for manufacturing have decreased, especially in relation to the growth of industrial production. Small companies, many of which have plants in congested areas, have switched from coal to oil or gas. Part of the tonnage decline in manufacturing, however, is not a loss since it represents cases where company coal generating power plants have been closed because electricity can be purchased from coal-generated utilities more cheaply. Coal may not have done too badly with the manufacturers, all things taken into account. Electric utilities, on the other hand, have more than doubled their coal requirements since 1946 in spite of great strides in generating efficiency.

The electric utility market was one where interfuel competition was at its strongest during the past decade. Modern utility plants are designed to burn almost any kind of coal, and in addition, many are equipped to use oil and gas as well as solid fuels. What the utilities want is heat units—Btu's—and coal and oil and gas set out to get as much of this business as they could by quoting the lowest price. Cut-rate quotations made periodically on imported residual oil and an off-peak gas made the delivered prices to the utilities vary as much as 50 pct over the 10-year period. During the past year there has been more stability in the utility market because residual oil prices have strengthened due to the world demand for this fuel, and less off-peak gas has been available. Coal presently offers, with few exceptions, a price advantage to the utilities in the areas it ordinarily serves, and it has a reasonable chance to hold this advantage in the future.

Electric power has and will have a rapidly expanding market. It has effectively competed with oil and gas for uses like cooking, water heating, and certain industrial processing, and it now is branching into space heating and additional industrial uses. Coal as the major raw material for power generation can look to increasing utility sales and, by getting them, it indirectly will be recapturing business it lost to oil and gas in the past. Economic progress seems to be leaning more towards coal, at least for a time.

Exports Increase

In 1955, the U. S. exported 51 million tons of bituminous coal as follows:

	Million Tons
Canada and other N. A.	17
South America	1
Europe	29
Asia and other	4
Total	51

Anthracite exports amounted to 3.2 million tons, of which 2.5 million tons went to Canada. The latter country took most of the coke exports which aggregated only about 400,000 tons.

Prior to World War II bituminous exports consisted primarily of shipments to Canada with a small scattering of tonnage elsewhere, largely to South America. Canada still remains a good customer although its purchases have had a decline in recent years.

Shipments to Europe have fluctuated widely since 1946. Immediately after World War II, European exports, promoted through government aid, increased rapidly, reaching a record of 37 million tons in 1947. They were less than one million tons by 1950 but rebounded to 28 million tons in 1951 as defense programs prompted by the Korean War were underway. European exports again were on the decline after the Korean activity until a new development began to take shape late in 1954 when European economies were moving towards peak business levels. Europe, depending mostly upon its own coal for fuel, found that its mines had about hit their peak output. With industry booming and fuel needs expanding, it reached to America for coal and to the Middle East and Latin America for oil to supplement its fuel supply. Most of the coal taken from America is of high grade coking quality required in steel making. Those engaged in exporting feel that the European market has become an established commercial outlet and one that will continue to take a sizeable and perhaps an increasing volume of tonnage. To further promote this and other foreign markets, a group of coal and railroad executives, along with President Lewis of the Miners' Union, organized the American Coal Shipping Inc. last May for the purpose of improving the ocean transportation of coal. An objective of this company is to lower ocean freight rates which, during busy shipping periods in the past, represented over half of the delivered price on coal f.o.b. European parts.

Coal's Appearance Changes

Currently, the bituminous coal industry is stronger than it was a few years back, and it looks to further though gradual expansion in the years ahead. Its vulnerable markets are largely liquidated and its remaining markets consist of sales to growth industries. Higher costs will make oil and gas less competitive for uses where coal can serve as a raw energy. However, the liquidation in the railroad and retail markets, and the intensive competition of oil and gas for industrial uses—which took place in the past 10 years—caused alteration in the production as well as the distribution of bituminous.

During the postwar years, 1946 to 1948, bituminous coal like other fuels enjoyed prosperity. However, after 1948 and until 1955, when the economy was expanding and other fuels were increasing their sales, coal was on the decline and encountering the hardships that accompany continual market shrinkage. Employment was cut by one half and capacity was further reduced through the permanent closing of hundreds of mines. By 1954, the bituminous industry operated at a loss, many companies ceased operations and others were in financial difficulty.

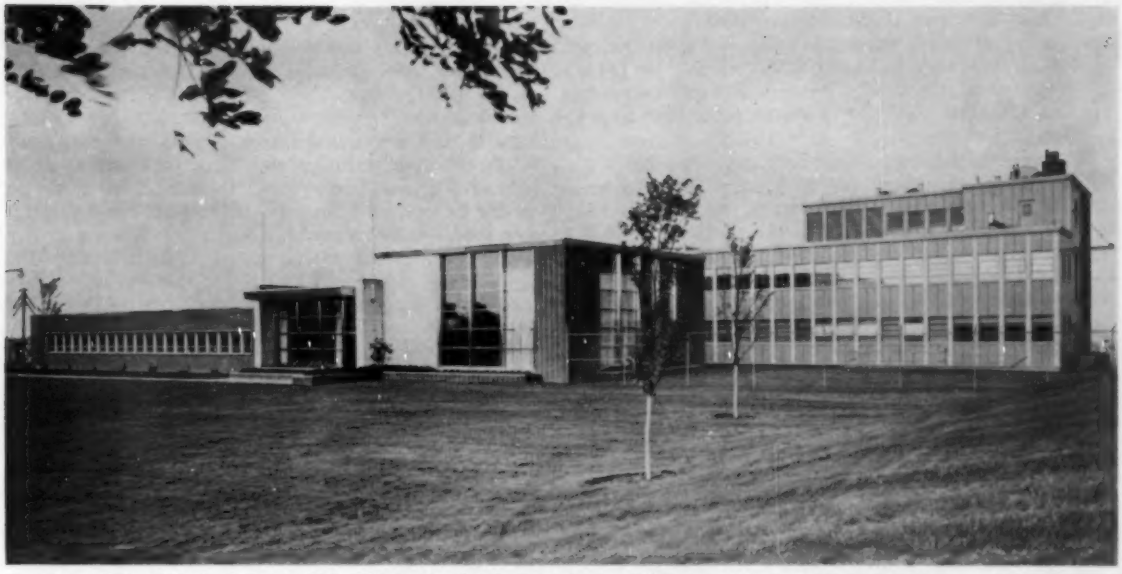
Decline resulted in dislocations as between the producing fields. An older field like Central Pennsylvania, with comparatively high costs, had a relatively larger decline than did fields where costs could be lowered. Some of the far western fields, that had depended upon railroads and retailers for most of their realization, were nearly removed from operating activity. West Kentucky and Ohio with

United States Consumption and Exports of Bituminous Coal

(Million Tons)

	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
1. Railroads, Class I	110	109	95	68	61	54	38	28	17	15
2. Retail Deliveries	101	99	90	90	87	77	68	61	53	54
Total (1 plus 2)	211	208	185	158	148	131	106	89	70	69
Pct Grand Total	38.9	33.9	32.6	33.5	30.8	24.8	22.8	19.3	17.8	14.6
3. Electric Utilities	69	86	96	81	88	102	103	112	115	140
4. Steel and Coke	92	115	117	99	112	121	104	119	90	113
5. Industrial and Other	129	137	122	108	107	115	105	106	88	101
Total (3, 4 & 5)	290	337	335	287	307	338	312	338	293	354
Pct Grand Total	53.5	54.9	59.3	60.7	63.9	64.4	67.0	73.3	74.4	74.6
6. Total U. S. Consumption (1-5)	500	546	520	446	454	469	419	427	363	423
7. Exports to Canada	22	26	26	16	23	23	21	20	16	17
8. Exports Overseas	19	43	20	12	2	34	27	14	15	34
Total Exports (7 & 8)	41	69	46	28	25	57	48	34	31	51
Pct Grand Total	7.6	11.2	8.1	5.9	5.3	10.8	10.2	7.3	7.9	10.8
10. GRAND TOTAL	542	615	566	473	480	526	466	461	394	475

SOURCE: U. S. Bureau of Mines (Figures may not add to total because of rounding).



Jones & Laughlin Steel Corp.'s $1.5 million research laboratory is reported to have the most modern equipment available for handling steel research problems. All phases of steelmaking are investigated.

the lower costs improved their positions. The large Southern Appalachian fields bettered their proportions in the national tonnage in years when overseas exports were large. Interesting to note is that mine productivity increased 70 pct during these years of market decline, partly due to the operators' continual search for improved efficiency and partly due to the closing of the less efficient mines.

As to the transportation of coal, the railroads lost while the highways and rivers gained relatively. There was an increase in the long distance transmission of coal-generated electric power, and the introduction of a pipeline for moving coal to market. Coal's high shipping cost is a major disadvantage in its competition with oil and gas, which have cheap transportation. Spurring coal forward to search for lower cost transportation was that the railroads made five general advances in coal freight rates during the period of the market shrinkage and, at the same time, were short in car supply in certain areas.

Impact of the market decline reflected in a coal price level that was shaky—steadily dropping as other prices soared in an inflationary spiral. The first mine price increase announced after 1948 which held became effective in September 1955. Between 1948 and the spring of 1955, price lists in many areas were reduced at least 10 pct, and the mine realization was lowered more because of the tonnage loss in the higher priced railroad fuel and prepared sizes for retail sales. Moreover, an addition was made to the heat value of a ton through advanced preparation, equivalent to a price reduction on steam coal and, since freight rates are on a per ton basis, a saving in transportation cost for Btu's shipped. While prices were declining, there were three general wage advances, and mine supply costs increased 50 pct. In the circumstances, considering competition and loss of sales, declining prices, increasing freight rates and mining costs, it was remarkable for the bituminous industry to survive as a private enterprise business, much less to appear with the vigor it has today.

The bituminous coal companies survived by improving operating efficiency, reducing and eventually erasing profits, by spending liquid reserves, and finally by running on a cash basis or at a loss as figured by complete accounting. It was fortunate for the industry that market improvement came when it did in 1955 because financial exhaustion was then being approached. This experience, while related to a series of events, demonstrated more than ever the consequences of an unstable price structure.

Coal prices have been featured for their lack of stability just as the coal industry has been known for its absence of profits. These conditions started when it took little capital to get into mining but they remained to plague the industry after mining became a business requiring a large investment. Today, it may take $10 or more per ton of annual capacity in particular areas to build a modern deep mine, and the mine may need sales up to 2 million tons per year to support the venture financially. A company has to be substantial to start such a mine—a reason for mergers—and it has to be profitable to attract capital to supplement its own resources in accumulating the total funds needed to finish the mine's development. Considering that mine capacity was reduced substantially during the liquidation of the early fifties, that many of the present mines are now nearly exhausted and will need replacement, and that additional capacity will be required for market growth, coal will have to attract upward of $1 billion in the 5 to 10 years ahead. This cannot be done with an unstable price structure that offers limited, if any, opportunity for profit. Coal has to develop a more practical price structure, and this important market change will have to be established soon.

Bituminous coal made general price increases following the wage advances effective in September 1955, and in April and October 1956. The first two of these price increases were maintained generally, and the third—recently made—is expected to hold, all of which indicate a start towards stability. These

increases, in terms of the greater heat units presently shipped to the consumer, will bring the price on steam coal only to about where it was in 1948. In comparison, other fuels have had price increases —some sizeable, and the general price level has jumped 18 pct.

Another important market change of the last decade is the tendency for coal purchasers to become fewer in number. Seventy of the largest coal customers now buy over half of the commercial tonnage. These customers use coal as a raw material for the making of energy and additional products. Coal is being used more and more as a raw rather than as an ultimate product, and its conversion is in the large utility, coke and chemical plants. These larger customers must be assured of a coal supply over a distant period which leads to long term contracts, a basis for the effective planning of mine production. Moreover, these customers utilize their plants throughout the year, resulting in a steady coal burn which has removed much of the seasonal slump that used to characterize coal shipments. Using coal capacity more fully will provide cost savings beneficial to the customer and producer alike. Finally, the fewer and larger mining and consumer units, together with a steady flow of tonnage, gives the setting for transportation economies, such as might be realized through train-load freight rates and pipeline movement.

The bituminous coal industry little resembles its appearance of 10 years ago. Its market has a different pattern and further change can be expected as it starts towards a new growth. And to supply this changing market, production has been revamped and it will have further developments with the appearance of new mechanization and techniques. Capital needs will be great, which will place the emphasis on orderly selling and stabilized prices.

Safety Campaign Reduces Ground Fall Accidents

DURING 1956 results of the international safety campaign held in 1955 became available—a 29 pct reduction in deaths and injuries due to ground falls in mines! This was the impressive record of the 250 mines participating in the campaign sponsored by the Mining Section of the National Safety Council.

The goal was a 50 pct reduction of the 1954 frequency rate for injuries from falls of ground. Mines achieving this record and those operating during the campaign year without a chargeable injury from a fall of ground qualified for the National Safety Council's Certificate of Achievement. It was further required that a minimum of four safety activities be directed against this hazard. One hundred twenty-two mines surpassed the target or maintained a perfect record. Certificates of Commendation were presented to approximately 1000 supervisors who led their men through the year without a single chargeable injury.

Three out of four participating mines made progress against ground falls, although some did not reduce their frequency enough to qualify for an award.

As compared with past experience an estimated 260 injuries, including about 15 permanent disabilities and fatalities, were prevented by companies taking part. Some mines reported that the interest in safety aroused by the campaign lowered the number of injuries from other sources.

American mines as a group attained an average reduction of 30 pct from their base rate. Participating mines in the eastern U. S. showed marked improvement, averaging 46 pct. A 36 pct improvement was achieved by mines in the southwest—Arizona, New Mexico, Texas, and Colorado.

Canadian mines reduced ground fall accidents 24 pct. Nine mines in British Columbia achieved the largest average decrease—56 pct.

Four mines in South Africa, Cuba, Cyprus, and the Philippine Islands averaged 43 pct improvement.

Frequency Rates in 1955 Compared with Base Rates by Mining Areas

Mining Areas	Reduction, Pct
All mines	29
U. S. mines	30
Lake Superior	
Michigan, Minnesota, Wisconsin	24
Southwest	
Arizona, New Mexico, Texas, Colorado	36
Northwest	
Washington, Nevada, Utah, Idaho, California, Montana, South Dakota	22
Midwest	
Oklahoma, Missouri, Tennessee, Illinois	21
Eastern	
New York, Pennsylvania, Ohio, Virginia, New Jersey, and others	46
Canadian mines	
British Columbia	24
Ontario	56
Quebec	14
Other provinces	44
Foreign mines	43

* Average rates of mines reporting for two or more years prior to 1955.

Industry Research And Development For Bituminous Coal

by Harold J. Rose and James R. Garvey

UNITED States production of coal of all ranks has an annual value of about $2.5 billion at the mines. At the points of consumption, this coal, including the coke and other products obtained by carbonizing part of it, is valued at approximately $5 billion per year.

If, as many experts predict, the demand for coal rises to 600 million tons annually by 1960, the additional capital investment required for new plants to enable the additional tonnage and provide replacement of depleted facilities will exceed $2 billion. Additional huge sums will be invested in plant facilities to transport and utilize the additional production.

The future picture of the coal industry is painted in even more glowing colors by many. Their optimism appears to be substantiated by the influx of new money into the industry. A recent McGraw-Hill publication[1] reports "By the end of April of this year (1956) . . . . a big aggressive investment company had put at least $16.5 million into half a dozen of the better coal companies. Firms such as this now see a real opportunity for a price appreciation in coal investments."

Major research expenditures are needed to insure the efficient and economical production and use of the coal resulting from the predicted expansion. It is widely recognized that a greatly expanded program of coal research and development is essential to the security and continued prosperity of the nation. In 1952 the President's Materials Policy Commission in the "Paley Report"[2] stated that "Though the promise is great for major improvements in the use of the nation's rich coal reserves," several steps must be taken to bring this about, including "much greater effort to advance the technology of coal production, transportation, and use." The Commission recommended the cooperative "formulation of a strong program to advance coal technology to be carried out by a combination of private and public effort." In the Commission's opinion, a "positive approach to putting the nation's coal resources more fully to work through aggressive improvements in production and use is the only pattern that can be followed in light of the expansion of the economy that will have to be sustained." We agree with these conclusions, and further believe that the problems are such that participation by government, universtities, and industry research agencies are necessary.

HAROLD J. ROSE is Vice President and Director of Research, and JAMES R. GARVEY is Assistant Director of Research, Bituminous Coal Research Inc., Pittsburgh.

Current Coal Research

It is virtually impossible to obtain complete figures on the amount of money being spent each year for coal research. Many coal companies as well as many coal users do not maintain separate research ex-

penditure records. In addition, some companies, to protect their competitive position, are reluctant to release data concerning research expenditures.

However, a joint survey of current research on bituminous coal was made this year by the U. S. Bureau of Mines in cooperation with Bituminous Coal Research Inc. Confidential information on research expenditures, projects, and professional manpower was obtained by the interview method. A published summary[3] includes the following information on sources of research and development funds:

Sources of Funds for Bituminous Coal Research

Commercial Coal Producers	$ 2,452,284
Captive Coal Producers	1,206,888
Equipment Manufacturers	3,220,810
Other Industrial	4,954,954
Total Industry Funds, annually	11,834,936
Federal, State, University, and unidentified funds	5,547,464
Total, All Sources	$17,382,400

The above are minimum figures, since eight of the organizations contacted did not supply data, and some may have been overlooked. However, these figures are the most recent and reliable that are available.

Accurate data as to where and on what type of problems the industry is concentrating its research expenditures are not available. However, it can be concluded from the USBM-BCR survey that the coal industry is participating in projects which comprise 85.7 pct of the total amount being spent. Research projects cover mining, preparation, storage, transportation, combustion, coke and coal chemicals, gasification, and hydrogenation. The industry does not, so far as can be determined, participate in research projects covering coal resources and the physical and chemical properties of coal, which categories account for 14.3 pct of the total annual research expenditures.

Some comment on what constitutes the aforementioned research categories in which the industry is participating would be appropriate.

Mining research accounted for $3,038,700 of the total, or 17.5 pct. As would be expected, over half of this was devoted to continuous mining and methods and machines and associated problems. Other projects included transportation, roof control, safety equipment, acid drainage, and drills.

Preparation research accounted for $606,400 of the total, or 3.4 pct. The major portion of this was evenly divided between fine coal cleaning and fine coal drying.

Storage and transportation research accounted for $97,900, or 0.6 pct of the total. It is significant that one of the major cost items connected with delivered coal received such limited research attention. Everyone its talking about the problem, but so far as can be determined industry is doing little about it.

Combustion research accounted for $1,121,800, or 6.4 pct of the total. This money was spread over the various combustion markets from residential to utility. Of the more than 420 million tons of coal produced during 1955, slightly less than 70 pct was sold in markets requiring conversion of the energy to heat by combustion. Earlier we pointed out that the bituminous coal produced last year had a market of about $5 billion. While it may not be entirely accurate to assume that the market value of the coal which went to combustion markets was 70 pct of this total, certainly it is close enough to conclude that the value warrants more research effort than the survey disclosed.

Coke and coal chemicals research accounted for $5,435,400, or 31.3 pct of the total. Most of this was fairly well divided between high-temperature and low-temperature carbonization.

Gasification accounted for $2,517,900, or 14.5 pct of the total, and **hydrogenation** accounted for $2,080,100, or 12.0 pct of the total.

The industry participated in research projects under the various categories above to the extent of $12 million in 1955. This amount is gratifying, and important accomplishments have been and are being attained with this expenditure. However, the rate of effort is not in keeping with the needs and opportunities. By way of comparison, research expenditures in 1953 by several other industries were, according to the National Science Foundation[4]:

Petroleum products and extraction	$145.9 million
Stone, clay, and glass products	$ 38.0 million
Chemicals and allied products	$361.1 million

Division of Areas of Research

It is not generally realized how many types of research and engineering activities, laboratory facilities, skills, and viewpoints may be required to convert a *research possibility* into a commercial process or product. (Or to establish that it is not economical under present conditions.)

Fig. 1 shows typical steps or phrases which are usually involved in advancing a research project from the original concept to the stage of commercial use. Consideration of the many phases listed in this diagram will show why a majority of projects of broad interest will benefit by the participation of various types of research organizations.

Fig. 2 lists types of organizations which are already handling research and related activities pertaining to coal. It also suggests the phases of research which are particularly appropriate for each type of organization to handle.

It must be understood that the diagram is merely illustrative, and is not intended to be complete. For example, it does not show transportation agencies, although transportation usually represents an important percentage of the cost of coal at the point of use. Leading coal-carrying railroads have been important contributors to and participants in research projects to increase and improve the use of coal.

The recent cooperative study made by the Bureau of Mines and Bituminous Coal Research, Inc., included the listing of 209 coal research possibilities which it felt merited further consideration. These by no means comprise all coal research opportunities in their respective fields, and some needed technical activities were omitted because they did not come within the scope of the assignment.

No suggestion was made in this study as to whether industry, universities, or state or federal organizations would be best equipped to work on a given problem. However, since the publication of this study, the present authors have made a preliminary analysis of each of the 209 research possibilities, to suggest which types of organizations could probably handle each project to best advantage.

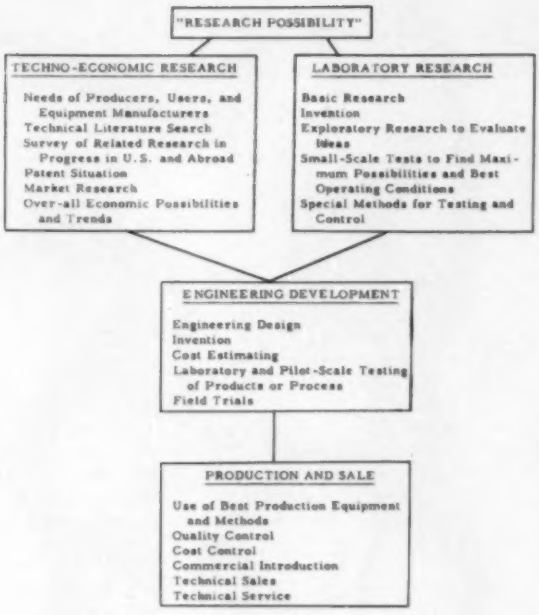


FIGURE 1. STEPS IN RESEARCH, ENGINEERING DEVELOPMENT, AND RELATED ACTIVITIES to convert a "Research Possibility" into Commercial Use

The conclusion reached is that for 60 pct of the topics both government and industry activities were desirable to handle appropriate phases of the broad research, development, and evaluation.

For 29 pct of the topics, it is felt that industry (associations, equipment manufacturers, coal companies, large coal users, transporters, etc.) could handle the research and development work. In these cases it is not presently obvious that major new government research will be needed for acceptable handling.

For 7 pct of the topics, it is believed that government (federal, state, and university) organizations could handle the research work. In general these topics are specialized in scope and do not include the commercial application of the results.

Research for Principal Markets

The areas of research in which the industry is most interested are those most nearly related to the markets. By and large the research expenditures by the industry reflect this interest, either in equipment development for better utilization or mining and preparation research to produce a product for specific markets. The need for research is best discussed by considering each of the markets.

Utility power markets in 1955 consumed over 140 million tons of coal. The report of the president's Materials Policy Commission suggested that coal consumption to produce electricity would reach 320 million tons by 1975. A more recent figure based on revised estimates of power needs of the future[8] places the total coal consumption for utility power at 430 million tons by 1975.

But the recent advances in nuclear power generation have created some pessimism on the part of many as to whether the coal industry will obtain the expected share of the utility market. The long-range possibilities of nuclear power generation should not be underestimated, but rather they should serve as a stimulus to the industry to vigorously attack the problems connected with the use of coal for power generation. Research has been responsible for steadily increasing efficiencies of coal-burning generating stations. Further research in air pollution, coal storage and handling, as well as combustion, will enable continuation of coal dominance in the power generation field.

The **railroad market** declined a little further last year to 15 million tons. Research activity has been very limited. Work on the coal-burning gas turbine is being continued by the Locomotive Development Committee of BCR. Recent test results indicate that the many problems encountered in this project have been overcome and one of the larger railroads is considering the purchase of a unit for road trial.

The Norfolk & Western Ry. is continuing its tests of the coal-fired steam-turbine locomotive. Time and economic considerations will resolve the question as to whether this locomotive, or modifications of it, has a lasting place in the motive power field.

The importance of dependability of fuel supply for motive power in the interest of national security is recognized. Coal-burning equipment alone can provide this dependability.

Coke plants and steel mills last year consumed approximately 120 million tons, about equal to the previous peak years of 1951 and 1953. This market, the second largest user of coal, receives proportionately more research attention than do the other markets. Perhaps one reason for this is the fact that many producers of coal for this market are their own customers, as a result of captive mining operations. Much still remains to be learned about the use of the so-called non-coking coals and the use of higher sulfur coals either directly or after treatment.

In addition, the knowledge of low-grade ore processing is still limited. Since current methods for producing commercial iron-ore concentrate from taconite rock require 160 lb of solid fuel in addition to 11 to 16 kwh and 2 to 2½ gallons of liquid fuel or equivalent per ton of prepared ore, this becomes a coal research problem, both directly and indirectly. It has been predicted that 17 to 20 million tons of concentrate will be produced annually by 1960.

Other industrial markets for coal consumed approximately 92 million tons of coal last year. Because we believe the markets overlap, and we will discuss this a bit more later, we will add to this tonnage the 54 million tons shipped for retail delivery, making a total of 146 million tons used by a *catch-all* market. Despite the size of this over-all market, surprisingly little is known about it. It consists of customers who use as little as 4 or 5 tons of coal per year to industrial consumers using several hundred thousand tons. Most of these customers use coal as a source of heat energy, and the fact that the tonnage is now about 65 pct of what it was in 1947, and is dropping fairly steadily despite a growing market for fuel, indicates the need for more modern coal-burning equipment for the residential as well as the small industrial plants. More automatic residential equipment, package-type boilers for coal, and better, lower-cost coal handling and storage methods are but a few of the needs of this market that can be solved by industry research.

The preceding covers only already well established coal markets. Other markets which indicate the potential for rapid future growth, a potential which can be realized through aggressive industry research, include smelting, refining and fabrication

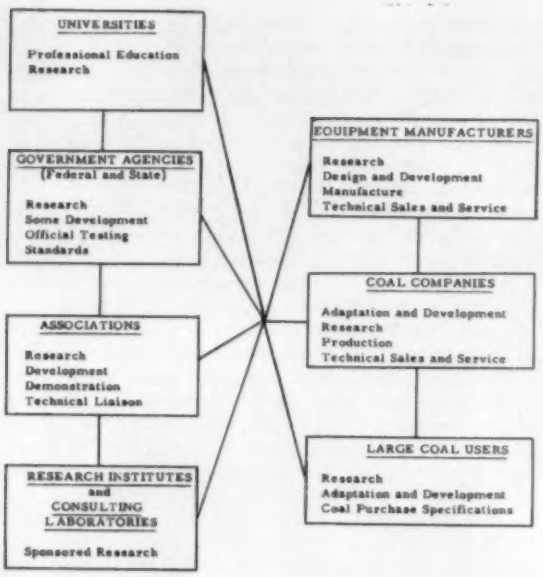


FIGURE 2. TYPES OF ORGANIZATIONS FOR HANDLING RESEARCH AND RELATED ACTIVITIES to Solve Coal Industry Problems and to Expand Markets
(Note: There is a flow of information in both directions between all groups.)

of metals such as aluminum and titanium, and the gasification, chemical conversion, and process uses of coal.

For example, the production of a ton of aluminum requires about 17,000 kwh and 1400 lb of quality carbon of several types. Aluminum production by 1975 is predicted at 3.6 million tons. Titanium production also requires considerable carbon per ton as well as twice as much power as does aluminum. Production of this relatively new metal is still small, but phenomenal growth is expected.

A surprisingly high percentage of the total research expenditure is currently being expended for gasification, chemical conversion, and process uses, despite the relatively small market which exists today. However, the potential use of coal in these fields is great and it has been estimated that by 1975 the demand for high-Btu gas would require 10 million tons of coal annually if produced by one of several gasification processes. Direct gasification to produce synthetic liquid fuels has been estimated to be of the order of 150 million tons of coal by 1975.

Synthesis gas made from coal or coke to produce synthetic methanol, ammonia, etc., will require approximately 20 million tons of coal annually at the end of the next 20 years. Other chemical uses of coal such as for the chemical reduction of ore for production of elementary phosphorus, electrothermochemical processes for the manufacture of such chemicals as calcium carbide and the production of new chemicals from coal by limited oxidation are other potential coal markets requiring research for complete development.

The foregoing discussion of industry research has emphasized the solution of technical problems. While some phases of this technical research have not received the concentration of dollars and manpower that many think is justified, substantial effort has nevertheless been made. But in market research, the prime tool used by almost all other industries to determine their marketing as well as their technical research policies, the coal industry has made only limited progress. One of the few market research men employed by the coal industry recently stated:[6]

> "Coal alone, of the three major fuel industries, cannot provide reliable consumption data in other than the national total by major use classifications. Two of these major use breakdowns are highly questionable, even for the total United States. Compare this to the oil and gas industries which have, for years, through well-organized associations, assembled information showing consumption by grade and use of products within each state and occasionally even smaller areas."

While the authors of this paper are not qualified as market researchers, we have been, as technical researchers, keenly aware of the lack of adequate market information for guideposts to technical research. Earlier we referred to the apparent overlap in our present industrial and retail market shipment data. More detailed information on the amounts of coal used by the many segments of these markets as well as more complete information on the equipment needs would enable concentration of research effort where it can accomplish the most. Today's research is done for tomorrow's markets. With limited knowledge of what tomorrow's markets might be, the research done today may be useless when tomorrow comes. For the most part, this needed type of market research activity should be an industry function, but assistance from government organizations, such as the U. S. Bureau of Mines, would be invaluable.

Conclusion

Although the experts do not agree on the exact magnitude of the U. S. energy increase expected in the next 20 years, all estimates indicate a 50 to 65 pct growth over present levels. The extent to which the coal industry will benefit from the increased energy demands depends to a large extent on the technological advances made in production, transportation, and utilization. The problems are generally known, but not all specifically defined. With careful planning and vigorous action, an adequate program of research and development on coal can do much to insure a strong and prosperous America in generations to come.

Earlier in this paper we mentioned the participation of the USBM and BCR in the preparation of a survey of current and possible future coal research. This experience was very gratifying to us, and on behalf of BCR we would like to take this opportunity to express our appreciation for the excellent cooperation which Mr. T. Reed Scollon and his associates at the Bureau extended. We feel that this has resulted in both groups having a better knowledge of each other's operations, which should make possible close coordination for an expanded government and industry research program to the benefit of not only the coal industry, but the entire United States economy.

References

[1] *How Coal Rebuilds Itself to Clinch Its Brighter Future*, Business Week, June 9, 1956.
[2] *Resources for Freedom, Volume I, Foundations for Growth and Security*, page 117, June, 1952.
[3] *Outlook and Research Possibilities for Bituminous Coal*, USBM IC7754, May 1956.
[4] *Science and Engineering in American Industry*, prepared by U. S. Bureau of Labor Statistics for National Science Foundation, page 14, 1955.
[5] *Can The Atom Compete?*: W. A. Raleight, Jr., Coal Age, page 55, January, 1956.
[6] *Marketing Research and the Coal Industry*: R. A. Pitcairn, Utilization, page 37, December 1955.

aime news

Gillson Named Jackling Award Lecturer

J. L. GILLSON

Joseph L. Gillson has been chosen to receive the Daniel C. Jackling Award. He will be the fourth person to be thus honored at ceremonies during the Annual Meeting. Dr. Gillson's lecture, *A Geologist Looks at Industrial Minerals,* will compare the limited interests of earlier economic geologists with the broader education required of all geologists today.

The award winner has been associated with E. I. du Pont de Nemours & Co. Inc. since 1929 when he joined the Development Dept. in Wilmington, Del. As a geologist for the company, he has made explorations in search of sulfur, ilmenite, fluorspar, and other raw materials as well as investigations of ground water supplies and foundation problems.

Born Feb. 12, 1895 in Evanston, Ill., Dr. Gillson received his B.Sc. degree in 1917, and M.A. in geology in 1920, from Northwestern University, Evanston, Ill. He then attended MIT which awarded him the Master of Science degree in 1921 and Ph.D. in 1923. He was a Navy lieutenant during World War I, after which he taught mineralogy at Harvard University. In 1923 Dr. Gillson joined the staff of Massachusetts Institute of Technology where he advanced from instructor to associate professor of geology, and worked concurrently for the U. S. Geological Survey. In 1940 he was appointed special geological advisor to the Indian Government.

Active in various professional societies, Dr. Gillson is now in his second term as vice president of AIME and was IMD chairman in 1947. In November 1956 he became president of the American Geological Institute.

Mining Branch Dinner Speaker Announced

The Honorable Felix E. Wormser, Assistant Secretary of the Dept. of the Interior, Washington, D. C., will be the featured speaker at the Mining Branch Annual Dinner on Tuesday, February 26, at the Roosevelt Hotel in New Orleans. His topic is *The Government's Role in Mining.* In discussing his forthcoming speech, Mr. Wormser promised to gear his remarks to his audience, which will include the distaff (the Mining Dinner is definitely not a stag affair).

A 1916 graduate of Columbia University's School of Engineering, Mr. Wormser received the school's highest award for "distinguished engineering achievement," the Egleston Medal, in 1956. He was also awarded the Columbia Alumni Medal in 1953.

Long prominent in mining circles, Mr. Wormser was vice president of St. Joseph Lead Co., and has been secretary-treasurer of the Lead Industries Association and the Metal Powder Association. He has served as Assistant Secretary of the Interior since 1953.

FELIX E. WORMSER

To Address All-Institute Meeting in New Orleans

B. Brewster Jennings, Chairman of the Board, Socony Mobil Oil Co., N. Y., will be the featured speaker at the AIME All-Institute Technical Session on Tuesday, Feb. 26, at 2:30 pm during the Annual Meeting in New Orleans. He will discuss one of the most pressing of current international problems—the Near East situation and how it affects world petroleum, in his talk, *Mankind's Stake in Middle East Oil.*

B. B. JENNINGS

A graduate of Yale, Mr. Jennings left school in 1917 to join the U. S. Navy and served overseas as an ensign on a submarine chaser. He returned to school in 1919, receiving his degree the following year.

Mr. Jennings has been associated with the company since 1920, beginning as a clerk in the marine department. Subsequently he became purchasing agent, and later manager of the real estate department. In 1935 he was appointed assistant to the president, and by 1939 was elected to the board of directors, in which capacity he supervised transportation for the company.

In 1942, Mr. Jennings left Socony to become Assistant Deputy Administrator for tanker operations of the War Shipping Administration. He returned in 1944, as a director, and resumed his management of Socony's transportation activities. That same year he was made president and chairman of the executive committee; retaining the latter post, he became chairman of the board in 1955.

Bylaws of the Society of Mining Engineers of AIME

Possible changes may be effected before final approval is given at the meeting of the AIME Board of Directors on Feb. 24, 1957.

Article I

Name and Object

Section 1. This Society shall be known as the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc., hereinafter referred to as *The Society*.

Section 2. The object of the Society shall be to furnish a medium of cooperation to those AIME members interested in the professional field of mining engineering, and to promote the advancement of mining engineering through professional meetings; to stimulate the preparation, reading, discussion, and circulation of technical papers concerned therewith; to advance education in the broad field of mining engineering; and to promote high standards in the profession.

Article II

Organization

Section 1. The Society shall consist of four Divisions and such additional Divisions as from time to time may be created. These four are to be known as:

a. The Mining, Geology, and Geophysics Division
b. The Minerals Beneficiation Division
c. The Coal Division
d. The Industrial Minerals Division

Section 2. Each Division shall be governed by its own officers and Executive Committee, operating pursuant to its Bylaws, under the jurisdiction of the Society. Each Division shall also operate in accordance with the Bylaws of the AIME. Bylaws and changes in Bylaws of the Divisions shall be subject to the approval of the Executive Council of the Society and of the Board of Directors of the AIME.

Section 3. A group consisting of at least 100 members of the AIME interested in a major field within the scope of the AIME may petition the Executive Council of the Society for recognition as a Division of the Society. Existing subdivisions or a group of subdivisions may also apply for Division status. Recognition of a new Division in the Society shall require the approval of the Executive Council of the Society and of the Board of Directors of the AIME.

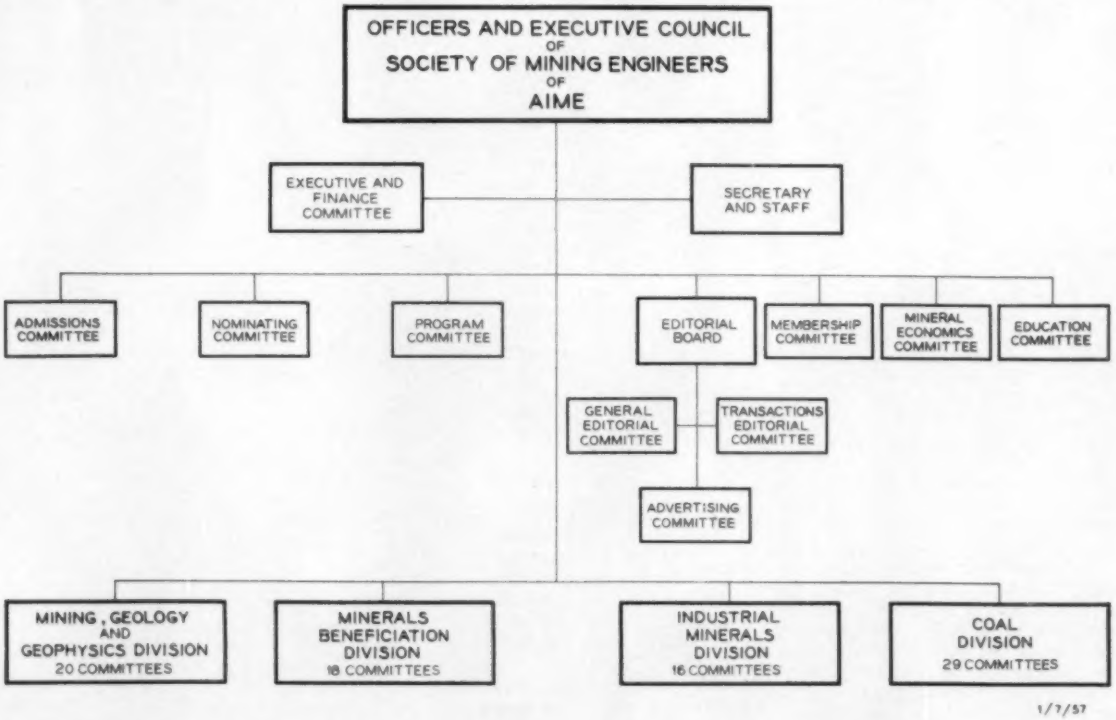
Article III

Membership

Section 1. Any member of the AIME in good standing may become a member of the Society by indicating his choice on the membership application form or by letter to the Secretary of the AIME. Otherwise he shall be considered a member of the Society if he chooses MINING ENGINEERING as the journal of his first choice among the monthly publications of the Institute.

The member shall be entitled to receive the magazine, MINING ENGINEERING, as that monthly publication to be furnished to him as part consideration for annual dues received, excepting that members of the Society affiliated with either or both of the other Societies of the AIME shall receive only the one monthly publication of their primary choice as part consideration for annual dues received. Additional subscriptions to any of the AIME monthly publications may be purchased by the member at the prevailing rate.

Section 2. Only members in good standing in the AIME shall have voting privileges in the Society.



Section 3. The status, rights, and privileges of individual members of the component Divisions of the Society are those defined in the Bylaws of the member Divisions, in these Bylaws of the Society, and in the Bylaws of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc.

Article IV

Officers

Section 1. The officers of the Society shall consist of a President, President-Elect, Past-President, three regional Vice Presidents, a Secretary, and a Treasurer.

Section 2. The President-Elect shall serve in successive years as President and Past-President. The succession shall be automatic.

Section 3. All officers of the Society excepting a President, a Past-President, a Treasurer, and a Secretary, shall be nominated and elected as provided hereafter in **Article IX.**

Section 4. A Secretary shall be appointed each year by the Executive Council (for Executive Council, see **Article V**), subject to the approval of the Board of Directors of the AIME at a salary consistent with his responsibilities.

Section 5. A Treasurer shall be appointed each year by the President of the Society from the Executive Council and with the approval of the Executive Council of the Society.

Section 6. The President of the Society with the approval of the Executive Council shall fill vacancies in any office of the Society, excepting that of President-Elect, occurring for any reason other than the expiration of term of office. (For Divisional Representatives, see **Article V,** *Section 2.* For representation on the AIME Board of Directors, see **Article X,** *Section 1.*)

Section 7. Vacancies in the office of President-Elect, occurring for reasons other than expiration of term, shall be filled by the Executive Council.

Section 8. In the event that the President of the Society resigns and his resignation is accepted by the Executive Council or his office is otherwise vacated, the Past-President of the Society shall immediately assume the duties and full privileges of President for the unexpired term. Under these circumstances the office of Past-President shall not be filled. (For representation on the AIME Board of Directors, see *Section 6* above and **Article X,** *Section 1.*)

Section 9. The terms of office for the President, Past-President, President-Elect, the Secretary, and the Treasurer shall be for one year; for the regional Vice Presidents and other members of the Executive Council of the Society, three years. The regional Vice Presidents shall be elected, one from east of the 84th meridian, one from the mid-continent, that is, between the 84th and the 102nd meridian, and one from west of the 102nd meridian. To provide continuity, one Vice President shall be elected each year. Initially the term of office for the Western regional Vice President shall be three years; for the Mid-continent regional Vice President, two years, and for the Eastern regional Vice President, one year. All terms of office shall start at the close of the annual meeting.

Article V

The Executive Council

Section 1. The Executive Council shall consist of the following persons:

a. President
b. President-Elect
c. Past-President
d. Treasurer (to be appointed from the Executive Council)
e. Three regional Vice Presidents
f. Representatives from each Division as described below:

All Divisions in the Society shall be entitled to representation on the Executive Council. Initially, the Mining, Geology, and Geophysics Division shall be entitled to six representatives; the Minerals Beneficiation Division, three representatives; the Coal Division, three representatives; and the Industrial Minerals Division, three representatives. These, together with the officers of the Society, shall constitute an Executive Council of 21 members. (See **Article XI,** *Section 6.*)

g. The Chairmen of all Divisions in the Society shall be invited to attend all Executive Council meetings; however, they shall not be considered members of the Council unless they have been designated as representatives as described above.

Section 2. In the event that a member of the Executive Council who was elected as a Division representative resigns or his seat on the Council is otherwise vacated, the Chairman of the Division represented by said member shall appoint promptly an acting member to fill the vacancy for the unexpired term. (For Officers of the Society, see **Article IV,** *Sections 6, 7, and 8.*)

Article VI

Finances

Section 1. The Executive Council of the Society shall be the custodian of all funds belonging to the Society.

Section 2. The expenditure of funds received by the Society shall be authorized by the Executive Council of the Society.

Section 3. Society dues or assessments in addition to the regular dues of the AIME shall be fixed by the Executive Council of the Society, subject to the approval of the Board of Directors of the AIME and the majority approval of the Society membership through a general referendum.

Section 4. Aside from or in addition to funds allocated by the AIME or the Society, any Division of the Society may, with the approval of the Executive Council of the Society, and with the approval of the Board of Directors of the AIME, raise or collect funds under its own management and control.

Section 5. The Chairman or the Secretary of a Division of the Society shall submit to the Executive and Finance Committee of the Society a financial statement at the Annual Meeting of the Society or at such other times as may be required by the Executive Council of the Society. The statement shall be submitted according to the forms used in the AIME accounting procedures.

Article VII

Standing and Special Committees

Section 1. There shall be two classes of committees: Standing Committees and Special Committees.

Standing Committees

Section 2. Standing Committees shall be as follows:

a. Executive and Finance Committee
b. Program Committee
c. Admissions Committee
d. Membership Committee
e. The three Committees of the Editorial Board (**Article VIII**)
f. The Nominating Committee (**Article IX**)
g. Education Committee
h. Committee on Mineral Economics

Tenure of members of Standing Committees, unless otherwise stated, shall terminate at the end of each annual meeting, but members may be reappointed at the discretion of the incoming President.

Section 3. *The Executive and Finance Committee* shall consist of the President of the Society, the Treasurer, and three members appointed by the President from the Executive Council and with the approval of the Council. Three members of the committee shall constitute a quorum.

It shall prepare an annual budget and inquire into, examine, plan for, and submit recommendations concerning the financial condition and welfare of the Society for consideration of the Executive Council. It shall be the duty of the Secretary and the Treasurer to furnish the committee with such statements and information as the committee may request.

All bills, accounts, and claims against the Society shall be examined, approved, and paid by the Executive and Finance Committee of

the Society, or by such officer or employee of the AIME as the Executive Council of the Society shall from time to time designate.

Section 4. *The Program Committee* shall consist of a chairman appointed by the President of the Society from the Executive Council and with the approval of the Council, and the chairmen of each of the Divisional Program Committees. It shall have the duty of coordinating program plans and providing for such joint programs and social events among the Divisions as are deemed desirable.

Section 5. *The Admissions Committee* shall consist of a Chairman appointed by the President of the Society from the Executive Council, plus two members from each Division. Each Division shall select two of its members to be approved by the Excutive Council. The committee shall formulate its own rules and procedures subject to approval of the Executive Council and of the Board of Directors of the AIME to whom it shall report its proceedings if required; otherwise the proceedings shall remain secret and confidential. Its recommendations for admission shall be submitted to the AIME Board for approval. No person shall be eligible for election to the AIME within one year after his name shall have been rejected by the Board of Directors of the AIME.

Section 6. *The Membership Committee* shall consist of a member selected from each Division, plus such other members as may be required to fulfill its purpose of coordinating Membership and Student Relations activities. A chairman shall be appointed by the President of the Society.

The President of the Society shall appoint one member of the Executive Council to this committee to serve as a contact councillor for the committee. This appointee may or may not be the chairman, at the discretion of the President of the Society, and appointment to this committee shall be for a term of two years.

Section 7. *The Education Committee* shall be appointed by the President with the approval of the Executive Council and it shall consist of a Chairman and a minimum of four other members, one to be selected from each of the four Divisions. This committee shall represent the Society on all matters concerning education in the mineral industry and shall be a liaison group between the Divisions, the Society, and the AIME Council for Education. It shall also have the responsibility for instituting positive and constructive programs for improvement in all phases of academic and professional education and training for the mining engineer.

Section 8. *The Committee on Mineral Economics* shall be appointed by the President with the approval of the Executive Council and shall consist of a Chairman and a minimum of four other members, one to be selected from each of the four Divisions. This committee shall represent the Society in all programs concerning mineral economics and shall be a liaison group between the Divisions, the Society, and the AIME Council on Mineral Economics. It shall assist in arranging for inclusion of papers and discussions on mineral economics at regional and Annual Meetings of the Society. This committee shall also endeavor to stimulate interest and promote progress in the broad economic aspects concerned with the search for, finding, developing, producing, transporting, refining, marketing, and the use of minerals.

Special Committees

Section 9. The Executive Council may designate from time to time such other committees as it may consider necessary or desirable. Special committees shall be held to a minimum in number, their duties clearly defined, and they shall be discharged as soon as the work for which they have been appointed is completed.

Article VIII

The Editorial Board

Section 1. The Editorial Board shall constitute a policy group for the publications of the Society. It shall define the editorial and publication policy and it shall advise and make recommendations to the Executive Council on appropriate matters. The Editorial Board or its delegated agent shall receive and record all papers and discussion tendered by the Secretary of the AIME for publication by the Society. It shall have charge of all functions in connection with the publication of MINING ENGINEERING. Execution of duties shall be accomplished by three committees: a Transactions Editorial Committee; a General Editorial Committee; and an Advertising Committee.

The Chairman of each of the above committees, the Editor of MINING ENGINEERING, and a member of the advertising staff of MINING ENGINEERING, together with the Secretary and Treasurer of the Society, shall constitute the Editorial Board.

The Chairman of the Editorial Board shall be selected by the President of the Society with the approval of the Executive Council and shall be also either the Chairman of the Transactions Editorial Committee or the Chairman of the General Editorial Committee. The Editorial Board shall have final authority, subject to appeal to the Executive Council and to the Board of Directors of the AIME, on the selection of papers for the Transactions, on the selection of all other editorial material, and in matters of policy with regard to advertising.

The Editorial Board shall have the responsibility of publishing the magazine, MINING ENGINEERING, on sound business principles and within the budget, and of negotiating cooperative intercourse between the technical journals of the other two Societies of the AIME. Editorial, advertising, and accounting facilities may be shared with the other journals of the Institute on appropriate basis, all at the discretion of the Editorial Board with the approval of the Executive Council of the Society and of the Board of Directors of the AIME.

The Editorial Board shall take office at the time of the Annual Meeting each year.

Section 2. Before the Annual Meeting of the Society, the Editorial Board shall submit to the Executive and Finance Committee a detailed statement of the year's operation of the publication projects. The Executive and Finance Committee may call for a financial statement at any time during the year. The Editorial Board shall assist the Executive and Finance Committee in setting up the budget for the magazine of the Society for the ensuing year.

In the event that the Editor of MINING ENGINEERING resigns or his position is otherwise vacated the Editorial Board shall recommend to the Executive Council a replacement. The Executive Council with the approval of the AIME Board of Directors shall appoint a replacement at an appropriate salary. The term of appointment of the Editor of MINING ENGINEERING shall be one year.

Section 3. *The Transactions Editorial Committee* shall consist of a Chairman who shall be appointed from the Executive Council by the President of the Society, the Editor of MINING ENGINEERING, and one member from each of the Divisions in the Society, all with the approval of the Executive Council. The representatives from the Divisions shall be appointed by the Divisions according to their established procedures. A member of the Transactions Editorial Committee (excepting the Editor of MINING ENGINEERING) shall not be a member of the General Editorial Committee or the Advertising Committee. The primary function of this committee shall be the selection of papers for the Transactions. This selection shall be based on the merit of such papers in the light of existing standards, with due consideration given to the recommendations of the Publications Committees of the various Divisions.

It shall be the responsibility of the Editor to publish papers selected for the Transactions only within the limit imposed by the annual appropriation for Transactions. In the event that the material exceeds this amount, the Editorial Board shall be so informed.

Section 4. *The General Editorial Committee* shall consist of a Chair-

man who shall be appointed from the Executive Council by the President of the Society with the approval of the Executive Council, the Editor of MINING ENGINEERING, and one member from each of the Divisions of the Society. The representatives from the Divisions shall be appointed by the Divisions according to established procedures. A member of the General Editorial Committee (excepting the Editor of MINING ENGINEERING) shall not be a member of the Transactions Editorial Committee or the Advertising Committee.

The primary function of this committee shall be to guide the publication of all editorial material of the Society other than the Transactions. It shall develop and execute long-range publishing programs for the *general-interest* material and shall endeavor to balance these programs within the various fields of divisional interest. The primary criterion for the *general-interest* editorial material shall be its usefulness to the profession.

Section 5. *The Advertising Committee* shall consist of a Chairman selected from the Executive Council who shall be appointed by the President of the Society, the Editor of MINING ENGINEERING, and a member of the advertising staff. In addition, the Chairman of the Committee shall appoint three members at large on a broad regional basis.

The primary function of the committee shall be to *guide and assist* in the development of advertising sales in MINING ENGINEERING. It shall serve as an advisory committee to the Society staff on advertising, sales programs, and policy, and it shall assist the staff in the implementation of such programs where possible. It shall assist the staff in making recommendations to the Editorial Board for sales promotion expenditures.

Article IX

Nominating Committee

Section 1. The Nominating Committee shall consist of two representatives from each Division, with the exception of the Mining, Geology, and Geophysics Division, which shall have four representatives. The President and the Past-President of the Society shall also serve as voting members of the Committee. The President of the Society shall select one of the representatives from the Divisions to serve as Chairman. The Chairman of the Committee shall have full voting privileges. There shall be an alternate appointed for each representative.

Section 2. The members, and their alternates, on the Nominating Committee of the Society shall be selected by the Nominating Committee of each of the Divisions according to their regular procedures. The representatives on the Nominating Committee shall be selected by the Divisions at the Annual Meeting in February so that the new Committee can take office July 1st of each year. Letters of acceptance of the appointments shall be obtained from the representatives and their alternates in order to insure full representation on the Nominating Committee.

Section 3. In the event that a representative is unable to serve on the Committee, his accredited alternate shall become the representative. It shall be the responsibility of the President of the Society to verify the accreditation of the representatives.

Section 4. At an appropriate time, before the first of July, the President of the Society shall organize the new Nominating Committee by obtaining from the Chairmen of the Divisions the list of names of the representatives and their alternates.

Section 5. The Nominating Committee of the Society shall be appointed for one year and shall take office on July 1st. The committee shall meet in executive session during the Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc. The time and place of the meeting of the Nominating Committee shall be published in MINING ENGINEERING at least 21 days before the Annual Meeting and also in the printed program for the Annual Meeting.

Section 6. A two thirds vote of all representatives or their alternates on the Nominating Committee shall be necessary for the election of nominees. All members of the Committee must vote.

Section 7. The Nominating Committee shall designate nominees for President-Elect and one regional Vice President of this Society each year. (See **Article IV,** *Section 9.*)

Section 8. Each year this committee shall nominate one member to serve on the AIME Board of Directors as a representative of the Society at large. (See **Article X,** *Section 1.*)

Section 9. Each year two of the Society's representatives on the AIME Board of Directors shall be designated as Vice Presidents of the AIME. (See **Article X,** *Section 3.*)

Section 10. Every third year the Nominating Committee shall select a member of the Society as a candidate for President-Elect of the AIME. (See **Article X,** *Section 1.*)

Section 11. The names and biographies of the nominees shall be published in the July issue of MINING ENGINEERING. Any 25 members of the Society may submit additional nominations to the Executive Council for one or more of the positions specified above. Such nominations shall be submitted not later than September 1 of that year, and notice of the additional nominees for the position or positions designated shall then be published in the October issue of MINING ENGINEERING.

If additional nominations are not received by September 1, the President of the Society shall declare the nominees selected by the Nominating Committee elected automatically. If additional nominations are received, a letter ballot showing all nominees for the positions shall be sent on or about November 1 to all voting members of the Society in the United States, Canada, and Mexico. Ballots shall be returned within 45 days after they are mailed. The incumbent President shall appoint a tally committee to count the ballots, and the nominees receiving the plurality of ballots for each position shall then be designated elected by the Executive Council.

Article X

Representation on AIME Board of Directors

Section 1. The Society shall be represented on the Board of Directors of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc. by seven directors as follows:

a. Every third year in rotation with the other two Societies, one member of the Society shall be elected President-Elect of the AIME, who shall serve after the first year and in successive years as President and Past-President of the AIME.
b. Past-President of the Society (serving for the third year)
c. President of the Society (serving for the second year)
d. President-Elect of the Society (serving for the first year)
e. Three members at large.

Should one of the six individuals listed under **b, c, d,** or **e** be elected President-Elect of the AIME, he will be replaced by appointment by the Executive Council.

Section 2. Each year, two of the Society's representatives on the AIME Board of Directors shall be designated as Vice Presidents of AIME, and shall serve for a term of one year.

Article XI

Meetings, Notices, and Quorums

Section 1. The Society shall meet as a regular and integral part of the Annual Meeting of the AIME and at such other times and places as may be determined by the Executive Council of the Society; however, the Executive Council shall meet at least twice each year.

Section 2. The annual business meeting of the Society shall be held during the Annual Meeting of the AIME at a time and place to be fixed by the President. For the transaction of business at such meeting, a quorum shall consist of a majority of the members of the Executive Council, together with ten members of the Society entitled to vote. In anticipation of this meeting, notice shall be sent to the members of the Society either through the regular mail or by publication in MINING ENGINEERING at least one month in advance of the meeting.

Section 3. A business meeting of the Executive and Finance Committee of the Council may be convened by order of the President, or by order of a majority of the Executive and Finance Committee at any time and in any place, and routine business transactions not inconsistent with these Bylaws or with the Bylaws of the AIME may be transacted. Actions of the Executive and Finance Committee shall require approval of the Executive Council at its next regular meeting.

Section 4. The President of the Society shall also call a meeting of the Executive Council, at such time and place as may be required, upon written requests of a majority of the voting members of the Executive Council.

Section 5. In respect to all meetings of the Executive Council, each member of the Council shall be notified by first class mail at least 21 days in advance as to the time, place, and agenda of the proposed meeting.

Section 6. A member of the Executive Council who was elected as a Division Representative on the Council may appoint an alternate from his Division to attend a specific meeting for him, but such alternate must be duly accredited by a written confirmation to the President or the Secretary of the Society from the Chairman of the Division that the member represents. The alternate shall exercise the same privileges as any member of the council during that session for which he is accredited. The privilege of proxy representation shall not be extended to the officers of the Society. (For replacement of the ex-officio members, see **Article IV,** *Section 6*).

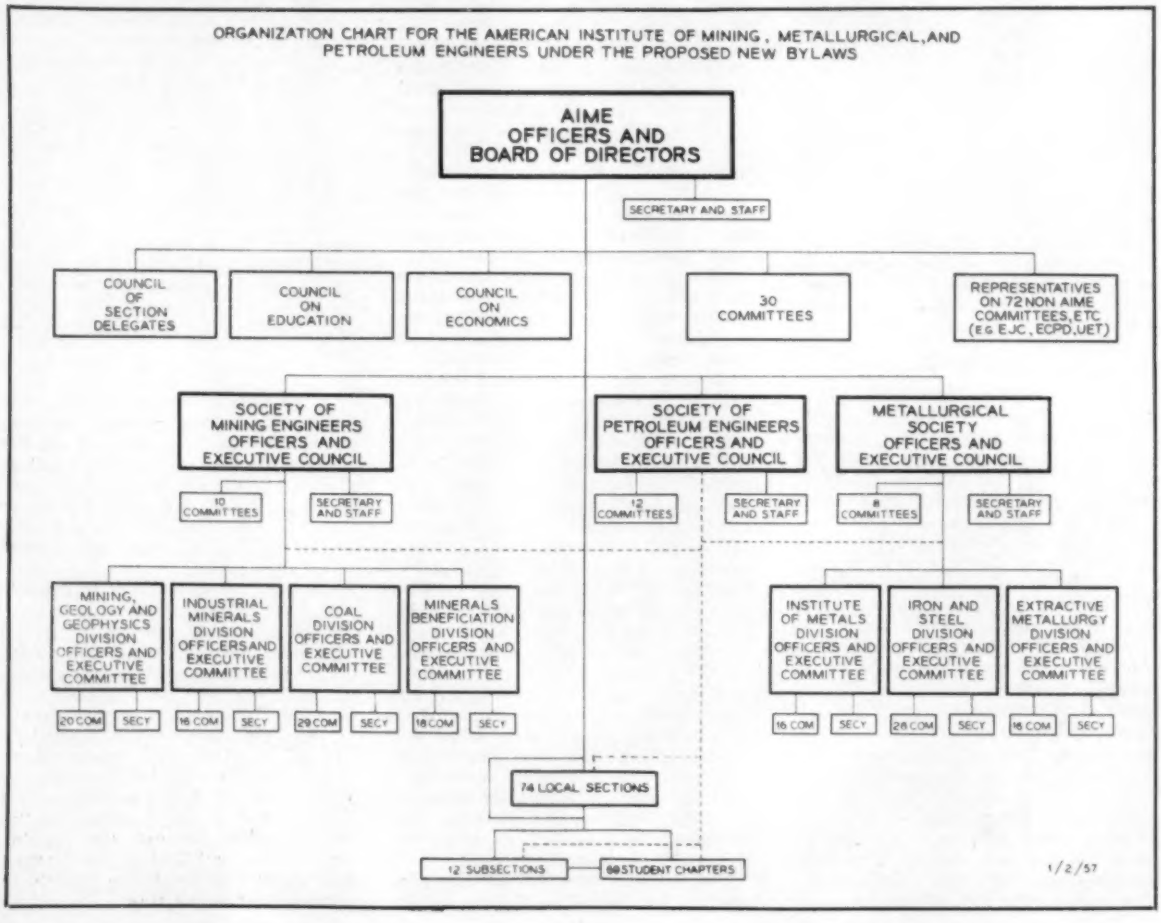
Section 7. A majority of the members of the Executive Council, including the accredited alternates, shall constitute a quorum.

Article XII

Amendments

Section 1. Proposals to amend these Bylaws shall be made in writing to the Executive Council of the Society and shall be signed by at least 25 members of the Society. Proposals for amendments may also be made by a majority vote of the Executive Council of the Society. These proposed Bylaw amendments shall be considered by the Executive Council and announced to the membership through the columns of MINING ENGINEERING together with any comments or amendments made by the Executive Council thereon. The amendments shall be voted upon by the Executive Council, or by letter ballot to the entire membership, as may be directed by the Executive Council. In either case the majority of votes cast on the proposals shall determine whether or not they shall be adopted or rejected. The Executive Council shall announce to the membership through the columns of MINING ENGINEERING the manner in which the vote shall be taken.

Section 2. Proposals to change the decisions, policies, or procedures of the Executive Council shall be made to the President or the Secretary in writing and signed by at least 100 members. Such proposals, unless they are acceptable to the Executive Council and are executed by the Council, or unless they are withdrawn within 30 days, shall be published with discussion by the petitioners and the Executive Council in MINING ENGINEERING within six months of the receipt of the proposals. Within two months from the date of publication of the proposals and the discussions a vote shall be taken by letter ballot of the membership of the Society. The majority of votes cast by the membership on the proposals shall determine whether they shall be adopted or rejected.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AIME OFFICERS AND BOARD OF DIRECTORS
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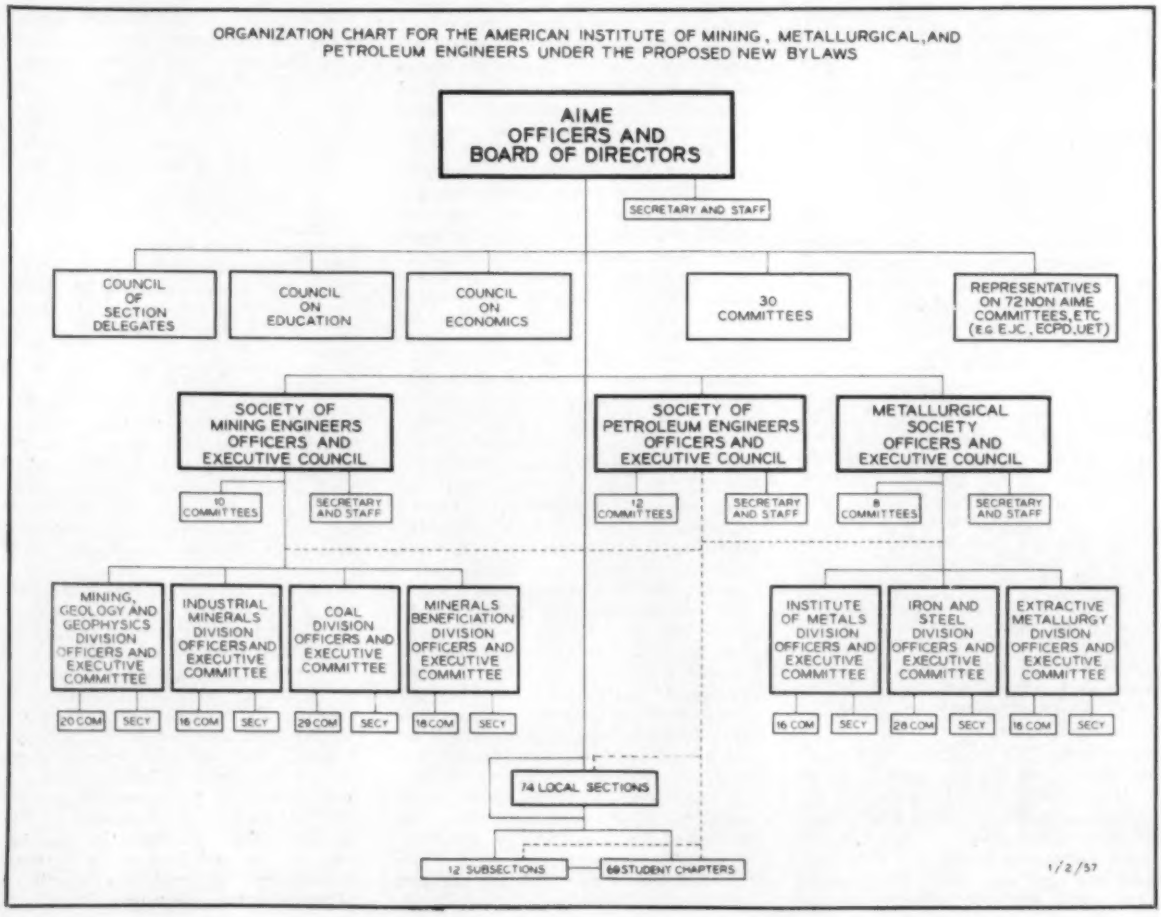
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ENGINEER*

"EJC's Report on What's Happening in Engineering"

*A Periodic Newsletter from Engineers Joint Council • 29 W. 39th Street, New York 18, N.Y.

(Contents prepared by Engineers Joint Council. AIME is a member.)

Survey of Engineering Profession

EJC Board and ECPD Council are proceeding to establish an operating committee for largest survey of Engineering Profession ever undertaken. To penetrate every aspect of profession, survey will take two years. Recommendations of Task Committee on Survey show many critical problems. Size and shape of future national product, the face of city and countryside, and even political power at world conference tables, will depend on future pattern of engineering. It's that important.

Busy B's (Election Extra)

Joseph W. Barker, ASME, and Fischer S. Black, AIEE, unanimously elected president and vice president of EJC for 1957 at Board meeting, Nov. 16. E. P. Lange, secretary; E. L. Chandler, treasurer; and L. K. Wheelock, assistant secretary, continue. Installation was on January 18.

EJC Third Annual Assembly

National forum for discussion of engineering professionalism and its relation to society. Topics: Place of the engineer, nationally in defense, on international, technological *cold front* and his income status. Speakers: Henry T. Heald, president, Ford Foundation; Maj. Gen. J. B. Medaris, and Wernher Von Braun, U. S. Army Ballistic Missile Agency; Prof. John Bell Rae, Case Institute of Technology; W. A. B. Iliff, vice president, World Bank; Philip Young, Commissioner, U. S. Civil Service Commission; C. W. Flesher, International Cooperation Administration; J. T. Duce, vice president, Arabian American Oil Co.; C. P. Dunn, president, International Engineering Co.; E. B. Peck, formerly Esso Research & Engineering Co.; D. R. Krotz, California Research Corp.; Frank Leamer, Bell Labs Inc. Dates: Jan. 17-18, with Assembly Dinner evening of 17th in Hotel Statler, New York.

Engineering and Science Closer

Engineering liaison with science firmer as a result of appointment of E. P. Lange as secretary, Section M, Engineering AAAS. This is a four-year working agreement, not honorary appointment.

1957 Nuclear Congress

Looks like biggest and best. Comprises EJC's Nuclear Engineering and Science Conference; NICB's Atomic Energy in Industry Conference; International Atomic Exposition; Hot Labs and Equipment Conference. 60 papers on handling radioactive materials and hot cell operations; 130 papers on fusion, high intensity radiation processing, use of educational reactors, reactor design, etc. Discussions on developing products through use of isotopes, legislation, nuclear power prospects, and new products through radiation chemistry. Time: March 11-15, 1957. Place: Convention Hall, Philadelphia. Write EJC, 29 W. 39th St., N.Y.

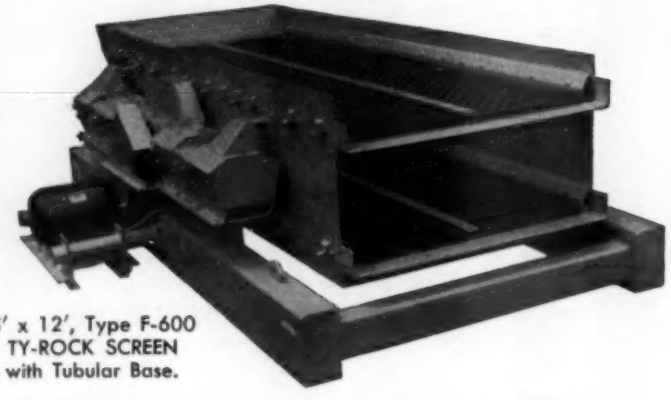
Add Labor Panel

Judge Burnita Mathews, U. S. District Court, D. C., has ruled against the National Labor Relations Board attempt to lump non-professionals and pros as bargaining group, upholding EJC's brief as "friend of Court" and EJC's position as written into the Taft-Hartley Act.

Help Wanted

ASEE has appealed to EJC for help in stemming exodus of teachers from schools to industry, confirming EJC-EMC Faculty Study (copies available at EJC, 29 W. 39th St. N. Y.) Suggestions wanted by ASEE Sec. W. L. Collins, University of Illinois, Urbana, Ill.

FOR PROFITABLE SCREENING USE



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Committee Plans Membership Activity at New Orleans

The past year has been a fairly successful one from the standpoint of new members. During 1956 your Membership Committee operated from a master prospect list and accelerated membership promotional work at the many Regional meetings.

During 1957, it is proposed to bring the entire membership of the AIME into actively promoting membership in the AIME. We will continue the use of the prospect list and expand our promotional work at the Regional, Society, and Local Section level.

Those of you who have any connection with membership activity in any way, whether on the Local Section, Division, or Society level, are urged to attend the Membership Committee Meeting at the Annual Meeting in New Orleans, scheduled to be held on Sunday morning, Feb. 24, 1957. Everyone is welcome and is urged to come and participate in the discussion. A lunch will be served to those in attendance. I am sure you will find it worth your while to come early to attend this meeting.

It is the hope of your Membership Committee that every nonmember in attendance at the Annual Meeting fills out an application before he leaves New Orleans. It will be to his advantage and to ours to have him sign up at this time. Your committee will have membership tables set up at the Roosevelt and at the Jung Hotel registration areas.

To do this, each and every member of AIME is urged to talk membership to anyone wearing a red-bordered badge. Application blanks will be available at the Membership Desk or from a Membership Committee member, who will be identified by the red streamer on his registration desk.

You as an individual can and should point out to the nonmembers in attendance the importance of belonging to the team. These nonmembers attending the Convention have already indicated their preference and are, therefore, our best prospects, but sign them up and don't accept anything less.

As members, and particularly those active on membership committees, you are also urged to give some of your time while in New Orleans to help man the desk activity. It will only take a few hours of you time and will be an important factor in the success of the membership work at this meeting.

Please cooperate by signing up after the Sunday meeting with Mr. H. N. Appleton.

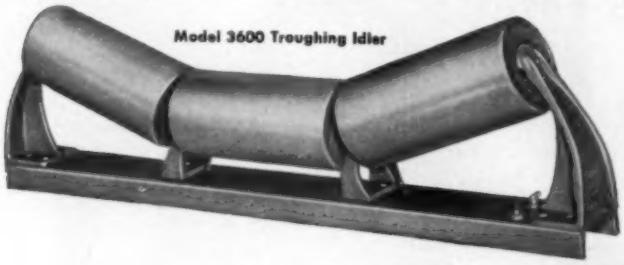
Let's help others enjoy the benefits of membership in AIME.

—**H. E. Johnson,** *Chairman, Mining Branch Membership Committee*

Petroleum Branch Offers Free Copies of Paper To All Aime Members

Separate copies of a 28-page paper entitled *Annotated Tables of Strength and Elastic Properties of Rocks* by Rudolph G. Wuerker, University of Illinois, are available from Petroleum Branch headquarters, 800 Fidelity Union Building, Dallas, Texas. The paper features the tabulation of results from standardized tests of strength and elastic properties of rocks. It discusses the importance of each property and its usefulness to the engineer as reflected in the existing literature. The tables list 21 properties which have been determined from rocks commonly encountered in mining, milling, and petroleum exploration.

Single copies of this paper are free to AIME members. For orders of more than one paper, the charge will be 25¢ per additional copy.



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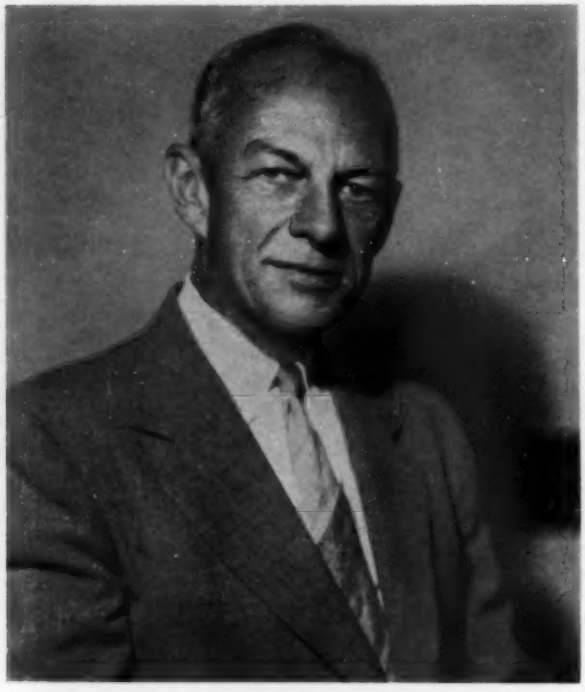
Institute Honors E. H. Robie



Edward Hodges Robie

WHEREAS, the Board of Directors of the American Institute of Mining, Metallurgical, and Petroleum Engineers takes note that the Secretary Emeritus of the Institute, EDWARD HODGES ROBIE, will retire November thirtieth, Nineteen hundred and fifty-six, after twenty-five years of devoted service,

RESOLVED, that the Board of Directors commends Edward Hodges Robie for his outstanding ability as Editor of *Mining and Metallurgy* from 1932 through 1948, and for his inimitable style combining wisdom and wit as author of "Drift of Things;" and

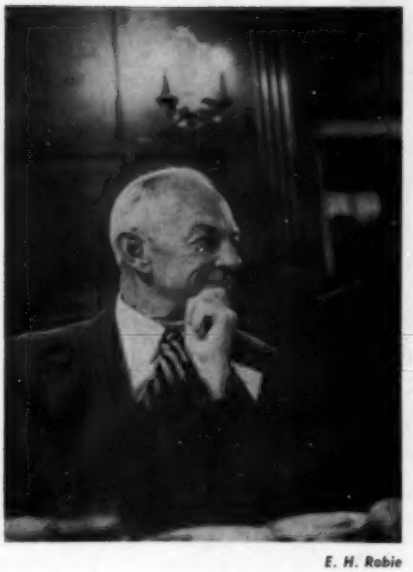
Expresses its sincere appreciation to him for successfully guiding the Institute as Secretary from 1948 to 1955 through a period of far-reaching development and growth.

November 16, 1956 **C. E. Reistle, Jr., President**

THE NEW YORK SECTION meeting on December 5 was the occasion of a salute to Edward H. Robie and his years of service to the Institute. President C. E. Reistle, Jr., on behalf of the Directors, presented Mr. Robie with a *hi-fi* set in token of their personal appreciation and esteem. These candid pictures taken during the meeting show some of the members present with Mr. Robie on this occasion.

President C. E. Reistle, Jr.

H. DeWitt Smith and Mr. Robie

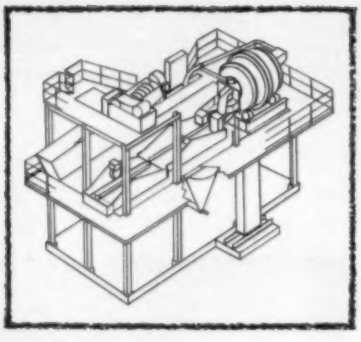


E. H. Robie

Col. H. G. Moulton

H. Z. Stuart
New York Section Chairman

preferred



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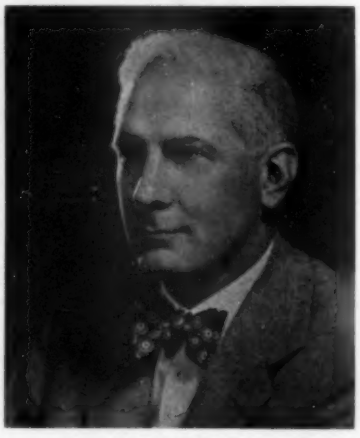
Institute Award Winners To

Richards Award to Gaudin

Antoine Marc Gaudin, the son of a distinguished French engineer and grandson of a pioneer crystal chemist, is to be honored with the Robert H. Richards Award. He received his Bachelor's degree in France, and an E.M. degree from Columbia University in 1921. Dr. Gaudin has contributed many technical papers to AIME and other publications in the course of his career as a research mineral-metallurgical engineer and teacher.

He was professor of metallurgical engineering, University of Utah, and mineral dressing at Montana School of Mines, after which he joined the faculty of MIT as Richards Professor of mineral engineering in 1939. In addition to this post, he is also currently a consultant to industry and government, here and abroad.



A. M. GAUDIN

Dr. Gaudin is best known for his contributions to the theory and practice of flotation, and for his books, *Principles of Mineral Dressing*, and *Flotation*. In recent years his interests have included hydrometallurgy, ion-exchange, solvent extraction, and metallurgical applications of radioactive isotopes. Dr. Gaudin believes that mineral engineering is not limited to any one kind of mineral or ore, or to any one way of solving a technological puzzle. His citation reads as follows:

"For his contributions as a scientist, educator, and author; specifically for his leadership and direction in the development of leaching and recovery techniques for low-grade uranium ores."

Geochemical Society

The admission of the Geochemical Society to the American Geological Institute, as a member society, was approved at the December AIME Board of Directors Meeting.

M. MORTADA

Mortada Wins Two Awards

Two of the Institute's most coveted awards will soon grace the home and the purse of young Mohamed Mortada, author of the prize winning paper, *A Practical Method for Treating Oilfield Interference in Water-Drive Reservoirs*. The Rossiter W. Raymond Award, consisting of a $100 cash prize and a certificate, is presented annually for the best paper by an AIME member under 33 years of age. A $400 cash award and a certificate comprise the Alfred Noble Award, given for the best paper by an author under 31, published by any of the Founder Societies and the Western Society of Engineers. Both awards go to Mr. Mortada for his paper, the first he ever submitted for publication, which appeared in the December 1955 JOURNAL OF PETROLEUM TECHNOLOGY.

The paper, cited by the award Committee for its originality, is the result of a research project undertaken by the author at the Magnolia Field Research Laboratory. Concerned with the problem of unexpected pressure values frequently found in oil well drilling, Mr. Mortada investigated the pressure effects transferred from one area to another by the water-bearing sands underlying the oil sands. This work produced a series of singular charts which enable oil producers to anticipate pressure changes at immediate and remote areas, thereby extending their control over production costs, oil recovery, and valuation.

Mr. Mortada's preparation for this fruitful investigation was begun at the University of Cairo in his native Egypt, where he earned a chemical engineering degree and petroleum refining option in 1946. He entered the University of California in 1947, to study petroleum production engineering. Mortada received both his M.S. and Ph.D. degrees in this field,

Be Honored at Annual Meeting in New Orleans

with minors in fluid mechanics, mathematics, and thermodynamics After a year of groundwork in operations of oil recovery at General Petroleum Co., the young Egyptian took a leave of absence to return to his homeland. Back in the U. S. in 1954, he was transferred to the Dallas research organization where he was able to carry out the project which had fired his imagination in 1953—a project which will be culminated by his ascent of the podium at the AIME Annual Meeting for these two high marks of distinction.

R. B. CAPLES

Douglas Gold Medal Awarded to R. B. Caples

Russel B. Caples has been chosen to receive the James Douglas Gold Medal. Born in Glasgow, Mo., in 1888, he received a B.S. degree in mining engineering in 1910, and in 1948, an honorary doctorate in engineering from Missouri School of Mines.

Mr. Caples worked in the testing and research departments, Anaconda Reduction Works, until 1914. During this period he collaborated with F. F. Frick and F. Laist in the development of the electrolytic zinc process. In 1953 he was transferred to the New York office of The Anaconda Co. as president of Anaconda Aluminum Co., and in 1955 became vice president in charge of metallurgical operations of all the Anaconda Co.'s properties.

A director of many organizations, including AIME, Mr. Caples' citation reads: "For distinguished achievement in extractive metallurgy, particularly in the electrowinning of zinc; and for outstanding success in stimulating the professional careers of many metallurgists."

A. FLETCHER

Andrew Fletcher Is Rand Medal Winner

The 11th recipient of the Charles F. Rand Gold Medal is Andrew Fletcher. The citation accompanying the award expresses his outstanding achievement in mining: "For distinguished administration in nonferrous mining and metallurgical enterprises; for his inspiring leadership in the mining industry; and for his outstanding contributions toward furthering the professional interests of those engaged in the mineral industries."

Since 1947, Mr. Fletcher has been president of St. Joseph Lead Co. A 1916 graduate of the Sheffield Scientific School, Yale University, he was awarded an honorary degree in engineering by the University of Missouri in 1949 and also received an honorary Doctor of Laws degree from St. Francis Xavier University, Nova Scotia, in 1953.

Currently an AIME director, Mr. Fletcher served the Institute as president in 1953. He is chairman of the Industrial Hygiene Foundation of America, vice president and treasurer, American Mining Congress, and president, Lead Industries Assn.

Washington Award Committee Appointed

President Reistle has appointed a committee composed of G. F. Moulton, chairman; T. B. Counselman and C. R. Dodson to offer recommendations for the 1957 Washington Award. This annual honor for "accomplishments which preeminently promote the happiness, comfort and well-being of humanity," is awarded jointly by the Four Founder Societies and the Western Society of Engineers. AIME members who have received this award include Charles E. Wilson, D. C. Jackling, and Wilfred Sykes.

Robert Peele Award To Louis A. Panek

Louis A. Panek will receive the 1957 Robert Peele Memorial Award for his paper, *Analysis of Roof Bolting Systems Based on Model Studies* (MINING ENGINEERING, October 1955). Born in Boston in 1919, he graduated from Michigan College of Mining & Technology in 1941 with B.S. degrees in mining engineering and geology, and a reserve commission in the Army Corps of Engineers. Then followed two years in construction of roads, airfields and fortifications in Panama, and a year as liaison officer and technical adviser with the Chinese troops in Burma.

In 1946 and 1949, respectively, Dr. Panek was awarded an M.S. and a Ph.D. in mining by Columbia University. Since 1949 he has been a research engineer, Applied Physics Laboratory, USBM. Dr. Panek's research on the theory and application of mine roof bolting has proved valuable in mine experiments for roof control problems. The Peele Award, to recognize significant achievement in authorship in the fields of mining, geology or geophysics, is given to encourage young men in creative work in these fields. It comprises a certificate and a check for $100.

L. A. PANEK

To Receive Hardy Medal

The Robert Lansing Hardy Gold Medal has been awarded to D. W. Fuerstenau of the Niagara Frontier Section. Morris Cohen, Chairman of the 1956 Award Committee, announced at the Board of Directors Meeting in December that Mr. Fuerstenau will be the first recipient of this award, with the approval of the Metals Branch Council. The Niagara Section will decide the time and place of presentation.

Arizona Section Holds Successful Annual Meeting

• The **Arizona Section** held its annual meeting on Dec. 3rd at the Pioneer Hotel in Tucson.

The guest speaker and AIME President-Elect Grover J. Holt, were accompanied by the Section Directors and other representatives of the state mining industry to the office of J. D. Forrester, Dean of the College of Mines, University of Arizona.

After a brief visit the party attended a meeting of the AIME Student Chapter where Mr. Holt addressed the mineral industry students. He spoke of our country's great need for engineers, the personal satisfaction to be gained from this career, and the many opportunities for graduates. He particularly emphasized the opportunities in the field of engineering research. At the meeting, attended by 131 students and faculty members, K. P. Sutton, chairman of the Student Chapter, presided.

Directors Meet

After lunch, the Arizona Section Directorate held their business meeting. They discussed the findings of the Long-Range Planning Committee, and the present status of the work of revising the AIME by-laws and rules. This discussion took the form of a question and answer period with President-Elect Holt clarifying many matters.

Technical Sessions

While the directors met, the five divisions of the Section held technical sessions at which time the following papers were presented: **Underground Mining Div.**—*An Underground Water Bulkhead Installation at the Copper Queen Branch,* by A. E. Himebaugh, Phelps Dodge Corp., Bisbee, Ariz.; *Mining Method Used on a Heavy Ground Type Ore Body and its Subsequent Filling by Deslimed Tailings at the Mineral Hill Mine,* by W. Anderson, Banner Mining Co., Tucson, Ariz.; *Ventilation and Air Conditioning at the Magma Mine,* by Bruce Short, Magma Copper Co., Superior, Ariz. **Mining Geology Div.**—*Geology of the San Manuel Mine,* by J. D. Pelletier, San Manuel Copper Corp.; *Marine Sonoprobe—A New Geophysical Instrument and Method,* by F. W. Hinrichs, Fairchild Aerial Surveys Inc.; *Oil and Gas Activity in the Four Corners Area,* by Carl B. Richardson, Consulting Geologist, Tucson, Ariz. **Smelting Div.**—*The San Manuel Smelter,* by R. C. Wilson, San Manuel Copper Corp. **Mineral Dressing Div.**—*Cyclone Practice in the Southwest,* by Russell Salter and E. King, Silverbell Div., A. S. & R. Co.; *Electrical Control Apparatus for Ball Mill Grinding Circuits,* by F. A. Littlewood, Cananea Consolidated Copper Co.; *Practical Thoughts on Grinding Ball Rationing,* by Walter L. Crow, Colorado Fuel & Iron Corp., Denver. **Open Pit Mining Div.**—*General Observations on Operations of Pima Mining Co. as an Open Pit,* by E. D. Spaulding, Pima Mining Co., Tucson, Ariz.; *Trends in Air Drilling,* by James Armstrong, Phelps Dodge Corp., Morenci, Ariz.; *Loading and Haulage at Ray, Arizona,* by R. I. Williams, Kennecott Copper Corp., Ray, Ariz.; *Recent Development in Rock Drilling at Chino Mines,* by D. D. McNaughton, Kennecott Copper Corp., Chino, N. M.

Among those attending the Arizona Annual Meeting were back row, left to right: T. G. Chapman, T. A. Sneddon, G. J. Duff, R. E. O'Brien, A. P. Morris, W. P. Goss, J. P. Pullen, K. Sutton, and J. B. Forrester. Front row, P. D. J. Honeyman, AIME President-Elect G. J. Holt, R. A. Harvil, C. R. Kuzell and J. A. Richards.

Dinner-Meeting

After a cocktail party from 6 to 7 pm, the evening dinner meeting was held. Over 700 members, including their wives and guests, attended. John A. Richards, chairman of the Arizona Section, presided. Those at the speaker's table were: President-Elect Grover J. Holt; C. R. Kuzell, vice president, Phelps Dodge Corp.; Richard A. Harvill, president, University of Arizona; Mrs. J. B. Cunningham, nominee for third vice president, National Woman's Auxiliary; Roy O'Brien, Field Secretary of AIME; Thomas G. Chapman, past Dean, College of Mines, University of Arizona; J. D. Forrester, Dean, College of Mines; Reed F. Welch, A.S.&R. Co., section secretary-treasurer; James Fletcher, Chairman, Underground Mining Div.; H. E. Metz, Chairman, Mining Geology Div.; F. J. Downey, Chairman, Smelting Div.; Henry Martin, Chairman, Mineral Dressing Div.; D. R. Purvis, Chairman, Open Pit Mining Division.

New Division Chairmen

The five chairmen were called on for a brief report on the activities of their divisions during the year, and the new division chairmen for 1957 were announced, as follows:

Mining Geology Div.—J. Ruben Velasco; Underground Mining Div.—E. Keith Staley; Open Pit Mining Div.—L. Ormsby; Ore Dressing Div.—E. V. Given; Smelting Div.—R. C. Wilson.

Election Results

John A. Richards, A. P. Morris and Walter C. Lawson were elected chairman, first vice chairman and second vice chairman, and Reed F. Welch, secretary treasurer, of the Arizona Section for 1957. The existing Board of Directors was re-elected, together with newly elected members: J. D. Forrester, E. D. Spaulding, A. B. Bowman, Reed F. Welch and K. Sutton.

President-Elect Grover Holt then addressed the meeting on *Iron Ore, Past, Present and Future.*

An evening of dancing followed, after which the Arizona Section members went "back to the mines" after this record meeting.

Student Section Meeting

The Student Section met again on Dec. 6 to hear an illustrated talk by J. J. Feketie, assistant employment manager, Cerro de Pasco Corp. Mr. Feketie addressed the more than 240 members, wives and guests, on the topic of his company's mining and metallurgy industry in Peru.

(Continued on page 284)

1957 Nuclear Congress Set in Philadelphia

Peacetime uses of atomic energy will be the topic of the 1957 Nuclear Congress, scheduled for March 11-15 at Philadelphia's Convention Hall. Coordinated by Engineers Joint Council, the session will bring together leaders in science, engineering, industry, government, education, agriculture and other fields.

Included in the Congress are four major elements, one being the Second Nuclear Engineering and Science Congress, sponsored by 20 engineering and scientific societies. During the five-day program 130 technical papers will be presented dealing with various phases of nuclear operations, from mining to the disposal of radioactive waste. Emphasis will be on new developments of potential value to civilian industry, especially in the fields of metallurgy, chemical processing, mechanical and power application.

The Fifth Hot Laboratories and Equipment Conference, sponsored by the Hot Laboratories Committee, Oak Ridge National Laboratory, Tenn., on March 14-15th, will deal with operation and development of equipment for atomic laboratories.

Walter G. Whitman of Massachusetts Institute of Technology, is general chairman for the 1957 Congress. President of the AIChE, he was also secretary-general of the U. N. *Atoms For Peace* Conference in Geneva, 1955. According to Dr. Whitman, "The 1957 Nuclear Congress will continue the remarkable cooperation among engineers and scientists from almost every portion of the globe and from every branch of science and engineering for the benefit of mankind, that was first evidenced at Geneva and later at the first EJC Congress in Cleveland in 1955. Progress in the civilian uses of atomic energy is being immeasurably expedited through this cooperative action."

Topics which will be covered by the Fifth Atomic Energy in Industry Conference are: fusion; recent developments in radiation chemistry and radio-isotopes applications, foreign and domestic markets for atomic energy products; nuclear propulsion; waste disposal; health and safety problems; the economics of new reactor types; the latest developments in atomic energy legislation; and problems in local and state atomic energy regulations.

The 1957 Congress expects representatives from other nations to participate in the meetings and to exhibit at the Exposition.

In addition to the four major organizations, the following partial list of organizations will be represented at the 1957 Congress: AIME, ASCE, ASME, AIEE, AIChE, ACS, ASM, IRE, SAE, ASTM, and the American Waterworks Assn.

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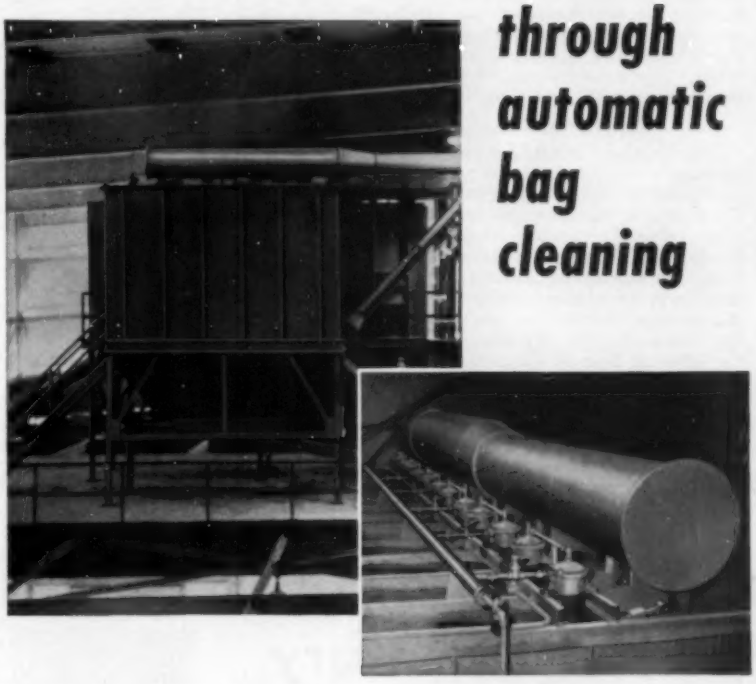

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NEWSLETTER

Dear Members of the
Industrial Minerals Division:

Chairman R. B. Ladoo called the last executive committee meeting at the Northeastern Mining Branch conference at Hershey, Pa. Smooth progress was evident in the reports of all committees, particularly the program committee report by T. E. Gillingham on plans for the annual meeting in New Orleans. Our Division will hold seven technical sessions, including a joint session with MBD. The next Executive Committee meeting will be held at that time.

Hershey Meeting

The Hershey meeting was a huge success, with attendance 60 pct above preliminary estimates. President-Elect Grover Holt brought a message that minerals people understand. In spite of competition from field trips, the session on Industrial Minerals was well attended and active discussions carried the program to the limit of time. At this meeting, the Mining Branch Council labored long over the final draft of new by-laws for the AIME Society of Mining Engineers which is to replace the present Mining Branch. This draft will be voted upon by the Board of Directors in New Orleans.

1957-58 Committee Chairmen

Last July, MINING ENGINEERING listed the new Divisional officers for 1957-58. It is a pleasure to report that a complete slate of committees has since been formed, and the only thing now lacking is the year's work for which we were chosen. The support of the entire Division is urged for the following chairmen and their members: T. E. Gillingham, Jr.—program; H. A. Meyerhoff—membership; D. R. Irving—divisional publications; R. S. Shrode—chemical raw materials; F. R. Hunter—ceramic raw materials; Mrs. P. Moyd—rare and radioactive minerals; Mrs. K. Mather—cement, lime, and gypsum; G. W. Josephson—mineral aggregates; W. T. Stuart—industrial waters; T. D. Murphy—fillers, fibers, and pigments; W. E. Ham—special sands and abrasives; F. Rockwell, Jr.—dimension stone and slate.

J. L. Gillson has organized an editorial board for preparation of a third edition of *Industrial Minerals and Rocks*, and assignment of chapters to authors was completed by January 1. Emphasis will be placed on changes in products, methods, and markets that have developed since 1949, the date of the second edition. In consequence there will be some changes in the number and scope of the commodity chapters.

Branch to Meet in Florida

The attention of our Division is already being focused on the Mining Branch meeting to be held next Oct. 15-18, at the Hillsboro Hotel in Tampa, under the sponsorship of the Florida Section. H. E. Uhland is general chairman for this meeting. If you have any questions about the desirability of attending, ask some of us who were in Tampa in 1949 for our Divisional meeting. The real question is how to get you home.

Much thought and discussion have been given to the matter of divisional affiliation as reflected in the membership of our own Division. Ours is set up on a commodity basis. The net result to the individual is somewhat akin to the old proposition of force versus object. Some favor uniformity, and others do not. This situation should have our serious study.

Please review the new Divisional directory, scheduled for issue some time this month, to see how many active industrial mineralizers of your acquaintance are not included. And that brings me to what I hope will be our theme for the new year —membership. More on that later. —*T. L. Kesler*

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Prospecting in Canada, *The Queen's Printer,* Ottawa, 401 pp., $2.00, 1956.—This illustrated 3rd edition supplies necessary and useful information to beginning and experienced prospectors. Tabular material is included.

The British Non-Ferrous Metals Directory, *Quin Press Ltd.,* 3rd ed., 317 pp., approx. $4.30, 1956.—This guide to British producers and suppliers is divided into two sections, the first of which is a classification by product with details of producers and merchants. The second part is an alphabetical listing of firms. Both raw and semi-finished metal products are included.

The Future of Arid Lands, ed. by G. F. White, Pub. No. 43, *American Assn. for the Advancement of Science,* Washington, D. C., 464 pp., $6.75, 1956.—This collection of papers and recommendations from the International Arid Lands Meetings presents the views of scientists from 17 countries on the ways and means of turning the world's arid areas into useful, productive assets.

Chemical Engineering Practice, Vol. II: Solid State, ed. by H. W. Cremer, *Academic Press Inc.,* 632 pp., $17.50, 1956.—This book, the second of a 12-volume series, is a compilation of studies by British scientists on various aspects of solid state chemical engineering. Sections on metals and metallic alloys, metal corrosion, porous masses, and powder metallurgy are included.

Metallurgy and Fuels, ed. by H. M. Finniston and J. P. Howe, *McGraw-Hill Book Co. Inc.* 785 pp., $21.00, 1956.—This volume, fifth in the *Progress in Nuclear Energy Series,* is a collection of papers on the problem of the reactor—the production of serviceable fuel elements, coolants, and moderators. In addition to studies of the elements, sections on the effects of irradiation and solid state physics are also included.

Structural Geology, by L. U. deSitter, *McGraw-Hill Book Co. Inc.,* 552 pp., $8.00, 1956.—Part I of this three-part treatise describes the physical properties of rocks. Part II discusses comparative structural geology, and Part III deals with the characteristics of the largest structural units and theories about their origins. Illustrations and 20 pages of references supplement the text.

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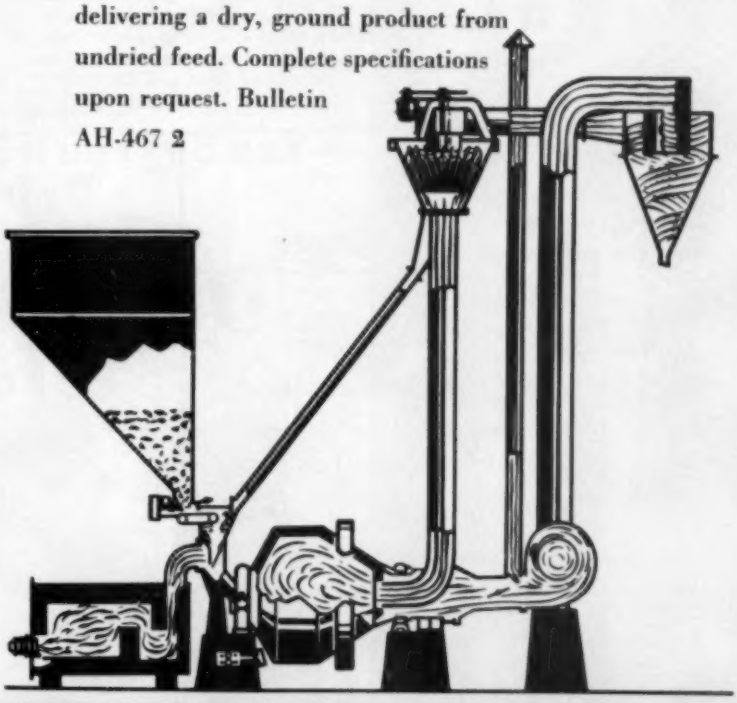

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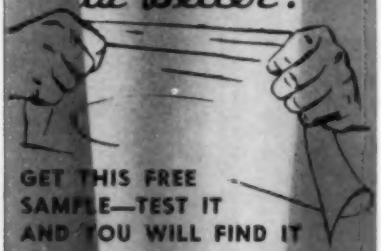

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PERSONALS

John Frassinelli has resigned as senior industrial engineer at the U. S. Steel Corp. coal mines in Gary, W. Va., to join the consulting firm of Robinson & Robinson, Charleston, W. Va.

Robert D. Saltsman has been named to the staff of Bituminous Coal Research Inc. as project engineer. He was formerly resident mining engineer for Youngstown Mines Corp., Dehue, W. Va.

Robert R. Beebe has joined the faculty of Montana School of Mines as an instructor and research associate, Mineral Dressing Dept. A member of the AIME MBD Education Committee, he had been employed in the Minerals Beneficiation Div., Battelle Memorial Institute, Columbus, Ohio.

Walter Lee is now with Kaiser Bauxite Co., Spur Tree, Jamaica, B. W. I.

Boris J. Kochanowsky, Mining Dept., Pennsylvania State University, spent last summer in Germany continuing his research in blasting. While there, he also delivered guest lectures at the University of Aachen and the School of Mines, Clausthal.

S. C. BERUBE

Stephen C. Berube is now Central Region manager, Le Roi Div., Westinghouse Air Brake Co., with offices in Milwaukee.

F. W. Goddard is now superintendent of the flotation mill, Parral, Mexico, unit of Cía. Minera Asarco, S. A., a subsidiary of American Smelting & Refining Co.

Jan P. Van Cruyningen has transferred from the Billiton Mining Co. ore dressing plant in Arnhem, Holland, to Mbeya Exploration Co. in Tanganyika, British East Africa.

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J. A. DRAIN

James A. Drain has been named vice president and general manager of the Mining and Construction Div., Joy Mfg. Co., Pittsburgh. **Hugo C. Nyquist** received a similar appointment in the Coal Machinery Div.

H. C. NYQUIST

B. W. Norton has advanced from general superintendent to vice president of Shenango Furnace Co., Sharpsville, Pa.

L. C. Jones, chief engineer, Utah Copper Div., Kennecott Copper Corp., has retired after nearly a half-century of service. A native of Utah, Mr. Jones joined the company's engineering department in 1908. Working his way up through the ranks, he was made assistant mine engineer in 1917, in which capacity he remained until he was appointed mine engineer in 1937. He was named chief engineer, Utah Copper Div., in 1952. During his 48 years with the company, Mr. Jones has witnessed and taken part in tremendous changes. He has seen a staggering total of 760 million tons removed from the great Bingham Canyon copper mine which formerly yielded 7,000 tpd and now is a 90,000 tpd operation. He had a part in the conversion from steam shovel to electric shovel mining, and assisted in engineering three tunnels out of the pit. The latest, just started, will be the longest single mine tunnel in the country.

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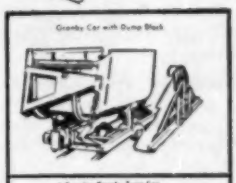

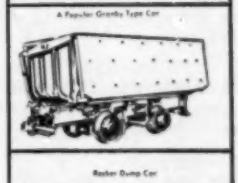

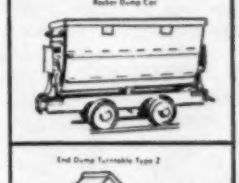

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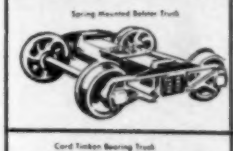

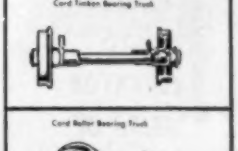

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Charles H. Dodge, until recently mining health and safety engineer, USBM, Pittsburgh, has been named valuation engineer, Tax Audit Div., Office of Internal Revenue. His assignment is the valuation of mineral properties and plants, with

C. H. DODGE

headquarters in Pittsburgh. A past vice president of the Pittsburgh Coal Mining Institute, he is a member of the National Mine Rescue Assn. and the National Institute of Mine Inspectors. He holds B.S. and M.S. degrees in mining engineering from the University of Illinois, and Carnegie Institute of Technology.

Luis A. Nogales, consulting engineer, is associated with the Barium Steel Corp. of New York. A native of Bolivia, Mr. Nogales is doing mine examination work in South America for the company and at present is stationed in Peru.

Thomas V. McEvilly and **Emil J. Mateker, Jr.,** were first and third prize winners, respectively, in the Society of Exploration Geophysicists' world-wide student essay contest. Both men are graduate students at St. Louis University.

F. R. Jones is mine manager, Stanrock Uranium Mines Ltd., Toronto. He had been general superintendent of MacIntyre Development, Tahawus, N. Y.

Homer S. Anderson is resident engineer for the New York & Honduras Rosario Mining Co., with offices in New York.

James W. Miller has joined the consulting firm of Robinson & Robinson, Charleston, W. Va. Prior to accepting this post, Mr. Miller was preparation engineer, USBM, Pittsburgh, for eight years where he supervised the experimental coal preparation pilot plant. In addition, he taught mineral dressing at the University of Pittsburgh.

George W. McCaa is in Moundsville, W. Va., as general manager of the Hanna Coal Co.

H. E. LEE

Harold E. Lee has been appointed vice president in charge of research and development at The Bunker Hill Co., San Francisco. A member of the staff since 1931, he had been manager of metallurgy, in charge of ore procurement and responsible for the company's reduction plants. Mr. Lee holds B.S. and M.S. degrees from the University of Idaho.

A number of personnel changes were recently announced by Kennecott Copper Corp. Among these were the following: **Thomas J. Hubbard,** former general master mechanic, has been appointed superintendent of the Magna Plant, Utah Copper Div., to succeed **John Allan** who retired after 43 years service. **Glen Wilson,** drilling and blasting foreman, Ray Mines Div., has been transferred to the Industrial Engineering Dept. at the Ray Plant for a year's training. **John R. Chambers,** who was transitman in the Engineering Dept., has been promoted to assistant drilling and blasting foreman at Ray Mines. In the mills mechanical and maintenance department, **Lorenzo Baldee** was appointed general master mechanic, with **R. L. Dean** to assist him. Mr. Baldee had been master mechanic at the Arthur Mill, while Dean had been working in the labor relations department.

D. D. McNaughton has been promoted from churn drill foreman to drilling and blasting foreman at Kennecott Copper Corp., Hurley, N. M., while **Theriot S. Melancon** advanced from junior engineer to assistant geologist. Another member of the Kennecott staff, **Paul Lemke,** recently presented a paper on the use of cyclone thickeners at the American Mining Congress in Los Angeles.

Arthur W. Heuck is in Hawaii as project engineer for Kaiser Aluminum & Chemical Sales Co.

G. M. DuBoulay has resigned his position with Frontino Gold Mines Ltd. to become mine superintendent at Masara Mining Co., Manila, P. I.

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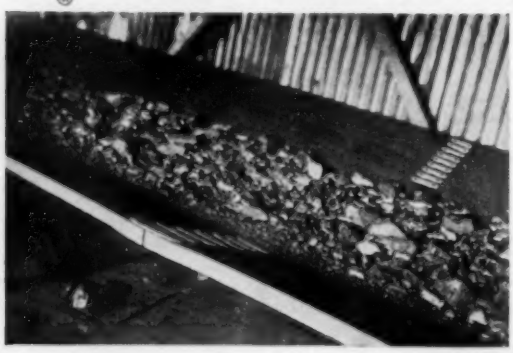

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Richard F. Wesner has been appointed general manager of operations, Boone County Coal Corp., Sharples, W. Va., where he has been serving as acting general manager since last May. Prior to joining the company in 1954, Mr. Wesner was employed by the McNally Pittsburg Manufacturing Corp., Pittsburgh, Kan., in charge of installation and servicing of preparation plants. During this service he became familiar with the Sharples, W. Va., company. A graduate of Pennsylvania State University, where he received B.S. and M.S. degrees, he is a vice president of the Coal River Mining Institute.

N. de Voogd has resigned as chief engineer-geologist with the Comité National du Kivu, Belgian Congo, and is now chief engineer for the La Luz Mines Ltd., Siuna, Nicaragua.

C. G. AMSTUTZ

G. C. Amstutz, formerly with Cerro de Pasco Corp. in Peru, has been named associate professor of geology at the University of Missouri, where he will teach economic geology, geochemistry, petrology and mineralogy in the School of Mines and Metallurgy at Rollo, Mo.

Charles Fairhurst has joined the staff of the Dept. of Mineral Engineering, School of Mines and Metallurgy, University of Minnesota, Minneapolis, where he will conduct courses in mine plant engineering. A graduate of Sheffield University, England, Dr. Fairhurst's principal research interest is in rock drilling. He was recently awarded the Sam Mavor Students Prize from the Institution of Mining Engineers, London, for his paper *Some Possibilities and Limitations of Rotary Drilling in Hard Rocks.*

Felix du Breuil is in the mining research and development department, The Jeffrey Manufacturing Co., Columbus, Ohio. He had been an associate professor in Pennsylvania State University's Dept. of Mining.

C. D. Michaelson, general manager of Western Mining Div., Kennecott Copper Corp., has been named Utah State Chairman of the 1957 Utah Crusade for Freedom.

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Albert J. Charles, formerly with the War Department, is now a geologist in Bradenton, Fla.

J. V. Zironi is with Minera Kino, S.A., Hermosillo, Sonora, Mexico.

Graydon L. Sallee, former general superintendent, AEC Uranium Concentrator, Monticello, Utah, is now plant superintendent, Lost Creek Oil & Uranium Co., Rawlins, Wyo.

Joseph F. Haseman, formerly head of the Minerals Separation Div., Foote Mineral Co., is now principal research engineer at the Florida Experiment Station, International Minerals & Chemical Corp., in Mulberry, Fla.

John C. Fox is assistant manager, Mining Div., American Metal Co. Ltd., New York.

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Around The Sections

(Continued from page 276)

Montana Section News

• The **Anderson-Carlisle Society,** student chapter of the Montana School of Mines, re-inaugurated a public open house at their school Nov. 2-3. Officially known as *E Day*, the program received the support of every department, and each presented a display prepared by the students and faculty.

Included were exhibits on flotation cells by the Mineral Dressing Dept.; plating bath offered by Chemistry; scintillator, and blacklight demonstrations by the Montana Bureau of Mines & Geology. The Mining Dept. showed mine models and equipment, while Physics featured electronic exhibits. In addition movies were shown each day on many topics including mining, manufacturing diamond bits, and the story of oil.

Refreshments were provided by the associated students, student wives club and the faculty women's club. The large turnout encouraged the Society to hold *E Day* annually.

• **Montana Section** members dined at the Meadow Lark Country Club in Great Falls on November 17th. With the Anaconda Co. providing cocktails and a turkey dinner, the evening meeting was charged with an atmosphere of conviviality. Frank Armes, assistant superintendent of Anaconda Wire & Cable Co.'s Great Falls plant, led off with a resume of Anaconda's entry into the aluminum business, and a description of the flow sheet of the new aluminum rod mill. The next speaker, Ed Casey, described the preparation and use of aluminum wire in power transmission at Anaconda. The session wound

A-T-S Cont'd.

up with an inspection tour of the aluminum rod mill at Black Eagle.

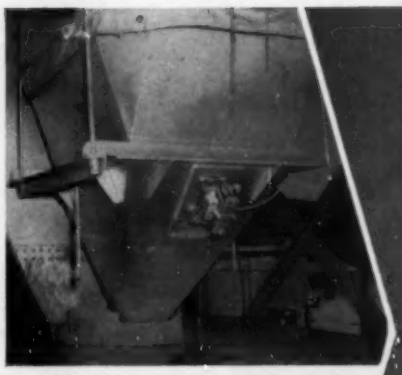
• Death was an uninvited guest at the close of the **Montana Section** annual election-dinner meeting, Dec. 15 at the Finlen Hotel, Butte, Mont. After ending the short business session, Section Chairman C. V. Saylor collapsed and died. Earlier in the evening he had presented the guest speaker, Lester Zeihen, research geologist, The Anaconda Co., whose topic was *The Romance of Precious Stones*. Mr. Zeihen illustrated his talk with displays of precious, semi-precious, and common stones. The lecture was followed by a film, *A Diamond is Forever*. Because two members of the nominating committee were unable to attend the meeting, it was decided to postpone the elections until the January meeting on the campus of the Montana School of Mines.

• The **New York Section** met November 15, at the Mining Club, at which time they heard guest speaker Tom Winston, foreign correspondent, McGraw Hill World News, discuss *The Situation in the Middle East*. Mr. Winston, who recently returned from Beirut, covered the background and current problems in that area, with particular emphasis on raw materials. This dinner meeting was also membership night, and all were invited to bring prospective members.

• More than 155 members turned out for the **San Francisco Section's** annual Christmas party on Dec. 12. The Engineers' Club was the scene of good fellowship and fun which began at 5:30 pm with cocktails and music. Dinner followed and a special floor show at 8 pm provided perfect entertainment. James P. Bradley, section chairman, presided.

The Section met again on January 9, at which time Gordon Fox, manager, Canadian Bank of Commerce, Alberta, Canada, presented an informative lecture on recent developments in the mineral industry.

• When the **Ajo, Ariz. Subsection** met on Dec. 13 at the Ajo Country Club, it was a social gathering held jointly with the WAAIME. Fish-house punch was served followed by a tasty pot-luck dinner. Arrangements for the dinner were made by Mrs. Patty Wine, Mrs. M. Gardner, and Mrs. Maria Simpson, while John Coppo and B. B. Hickman concocted the punch, assisted by W. C. Hunter and F. Rickard. After dinner the merry-makers gathered 'round for the breaking of the piñata, beautifully decorated by Mrs. O. Glenn, and Mrs. J. Rhoades. Swede Seaberg was the lucky man who finally broke the piñata, and a mad scramble for the goodies ensued. Dancing ended a thoroughly enjoyable evening.



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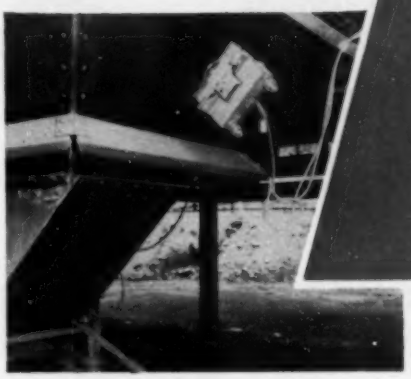

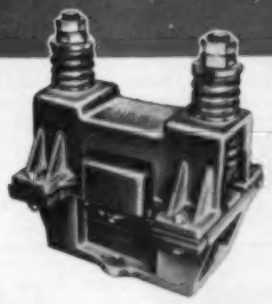

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OBITUARIES

Everett M. Paris

An Appreciation

by Henry R. Wardwell

Everett M. Paris (Member 1940), passed away Nov. 3, 1956, in Grand Junction, Colo., a victim of myaesthenia gravis. At the time of his death he was manager of mines for Union Carbide Nuclear Co. in the uranium field of the Colorado Plateau.

Ev was born Dec. 27, 1914, in Turners Falls, Mass., and was raised in Burlington, Vt., where he attended Burlington High School. Following graduation in 1933, he worked as an apprentice, carpenter, and plumber on house construction, until he was smitten with the urge to join the ranks of the mining engineers.

During the five years ending June 1940, Ev attended the Colorado School of Mines and worked as a contract miner in the mines at Idaho Springs, Gilman, and Climax. Following graduation from the School of Mines as mining engineer, he married Barbara H. Henderson on Nov. 16, 1940, in Boulder, Colo.

The Parises commenced their family life in Bisbee where Ev was called to service in the Army with the Corps of Engineers early in January 1942. He saw action in the North African and Italian campaigns. Discharged from the Army as a Captain in France, he was back in the States for Christmas in 1945.

Ev resumed his career as a mining engineer in January 1946 by joining the staff at the Pine Creek tungsten operations of U. S. Vanadium Co. near Bishop, Calif. In two years he progressed from miner to shift boss. Thereafter, he worked as shift boss until June 1948 at Park City for New Park Mining Co. and in Superior, Ariz., for Magna Copper Co. as level boss until the fall of 1948.

From Superior, Ev and Barbara rejoined the personnel of U. S. Vanadium Co., this time at Uravan, Colo., when Union Carbide was reopening the U-V mines in the Uravan Mineral Belt. As Mine Supt., Ev was responsible for supervision of a multitude of individually contracted sandstone mine operations in Southwestern Colorado and Southeastern Utah.

In April of 1953, the Parises moved to Grand Junction, Colo., where Ev was appointed manager of mines for Union Carbide Nuclear Co., a job which he ably accomplished until his untimely death. He served as chairman of the AIME Colorado Plateau Section and was an active member of the Congregational Church.

In addition to his wife, Barbara, Ev is survived by a daughter, Suzanne; two brothers, Franklin R. and LeRoy Paris; a sister, Mrs. Mildred Beck; and his mother, Mrs. Clara Paris. His memory will be long cherished by the mining fraternity and families, by the hunters and fishermen, and many other friends in the numerous camps he enlivened with his warm zest and comradeship.

Eugene A. White

An Appreciation by

D. A. Somerville

Eugene A. White (Member 1927) was born in West Union, Iowa, on Nov. 17, 1885. His death occurred in a Tacoma, Wash., hospital on Dec. 9, 1956.

He received his secondary and high school education in Iowa and his mining engineering at the University of Washington, from which he was graduated in 1908. Miscellaneous work kept him busy until 1910 when he obtained employment in the assay office of the Tacoma Plant, American Smelting & Refining Co. He served in various capacities and was general superintendent for about seven years. From 1932 until his retirement he was manager.

During the period when he was at the smelter, he became well acquainted with the mining and smelting fraternity on the Pacific Coast and particularly the Northwest, including British Columbia. He devoted much time to civic affairs, taking a very active part in the work of the Tacoma Chamber of Commerce and the Community Chest. He served his Alma Mater, the University of Washington, as a regent and thus was able to advance the interests of that institution.

Eugene White was perhaps most widely known for his leadership in the Masonic fraternity, being recognized as a Masonic scholar, philosopher, and speaker of note. He gave much time to the building committee of the First Christian Church of Tacoma and was a member of the Board of Trustees of the Tacoma General Hospital. He took a very keen interest in the affairs of the Institute and from 1945 to 1948 was an AIME National Director.

Mr. White is survived by his wife, the former Nellie Mae Dunlap; a daughter, Mrs. Eleanor Youngs of Seattle, and her four sons; his brother, Richard F. White; and two sisters, Mrs. Florence Meyers and Miss Frances White.

After "retirement" Mr. White could have spent his days basking in the sunshine of genial winter resorts or loafing in the summer-time on ocean-cooled beaches or beside mountain lakes. Instead he chose to remain active in fraternal and community service.

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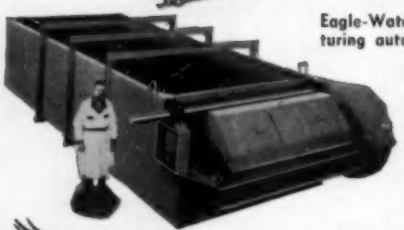

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Ned W. Andrix

An Appreciation by
Kenneth K. Landes

Ned Andrix (Member 1941), consulting geological engineer of Columbus, Ohio, and president of Ohio Mineral Resources Consultants Inc., died Jan. 8, 1956 of a heart ailment and kidney infection from which he had been suffering for some time. He is survived by his wife, Beatrice; a daughter, Mrs. Charles B. Carter; his mother, Mrs. August C. Andrix; and two brothers, Glen, and Frank, as well as a grandson, Bryant, born Dec. 30, 1955.

Ned Andrix was born at Lilly Chapel, Ohio on June 4, 1907. He graduated from Ohio State University in 1929, and joined the AIME in 1941. His professional life was an extremely active one; he worked mainly, but not exclusively, in the exploration for limestone, sand and gravel. At one time he formed and operated a core drilling company in addition to his consulting activities.

An able and energetic geologist, Ned Andrix's capacity for work was prodigious. At the same time he was the most spontaneously generous individual that I have ever known. His generosity covered not only material things; he was also generous with his time, work, and knowledge.

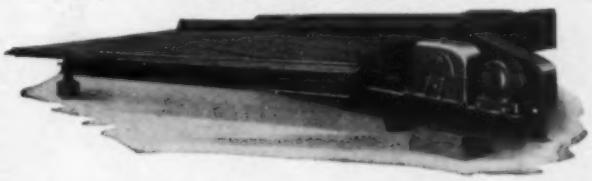
Necrology

Date Elected	Name	Date of Death
1955	S. E. Blamey	Sept. 2, 1956
1937	C. L. Boeke	Dec. 24, 1955
1929	Eugene E. Brossard	Sept. 19, 1956
1920	Douglas C. Corner	November 1955
1951	Jack Dankowitz	Unknown
1928	James E. Davidson	Unknown
1914	Everette DeGolyer Honorary Member	Dec. 14, 1956
1956	Victor C. DeMunck	Dec. 12, 1956
1936	Ernest V. Faraggi	August 1956
1956	E. R. Fritz	Dec. 7, 1956
1884	Joseph P. Gazzam Legion of Honor	Unknown
1937	L. A. Grelling	Mar 15, 1956
1947	George H. Hannum	Aug. 14, 1956
1894	J. Gordon Hardy Legion of Honor	Dec. 14, 1956
1917	Marden W. Hayward	February 1956
1951	Gerardo Heimpel	Aug. 31, 1956
1953	John B. Hicks	Nov. 26, 1956
1954	Woodrow Knott	Nov. 7, 1956
1906	Robert S. Lewis Legion of Honor	February 1956
1949	R. I. C. Manning	Dec. 8, 1956
1928	Thomas Morch	1944
1937	Ralph Neuhaus	June 16, 1956
1952	R. C. Nicholson, Jr.	Oct. 15, 1956
1940	Everett Paris	Nov. 3, 1956
1948	V. F. Parry	Unknown
1951	Ivor Pounds, Jr.	Unknown
1930	Charles F. Ramseyer	Dec. 9, 1956
1935	N. P. Rhinehart	Nov. 11, 1956
1953	Clarence V. Saylor	Dec. 15, 1956
1952	M. I. Signer, Jr.	Nov. 17, 1956
1948	William D. Steinle	Unknown
1942	J. Frank Tindol	November 1956
1927	Eugene A. White	Dec. 9, 1956
1944	Arnold Ziffzer	Dec. 17, 1956

Edwin J. Collins (Member 1909) died on August 15, 1956 at the age of 81 while attending the 53rd reunion of Michigan School of Mines where he received his B.S. and E.M. degrees. Mr. Collins was an engineer with Calumet & Hecla Co., the Calumet & Arizona Mining Co., and the Nevada Smelting & Mines Co. A consulting engineer until 1923, he became vice president and director of the Calumet & Arizona Mining Co. in 1923. During World War II, Mr. Collins worked with the USBM for three years.

Edwin W. Mills (Member 1904) died recently. He was born Sept. 30, 1876 in N. Wilbraham, Mass. Upon his graduation from Harvard University in 1902, Mr. Mills became a hydrometallurgist for Oriental Consolidated Mining Co. in Korea. He was subsequently employed by the Seoul Mining Co., Korea, and by Mills & Manning, Inc., Peiping, China. At the time of his death, he was consulting mining engineer for the Sheep Tanks Mines, Salome, Ariz.

James D. McClintock (Member 1944) died on July 2, 1956. On Dec. 18, 1900 in Matteawan, N. Y., he received his B.A. from Amherst College and did graduate study at the School of Mines, Columbia University. His career as a mining and metallurgical engineer for several southwestern mining companies led to his appointment in 1942 to the post of assistant chief, Metals Section, Mining Branch, WPB, and to a post with the U. S. Philippine War Damage Commission in 1948. At the time of his death, he was mining executive for Ventures Ltd., N. Y.



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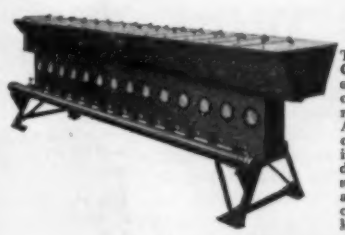

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Proposed for Membership
Mining Branch, AIME

Total AIME membership on Dec. 31, 1956, was 26,298; in addition 3,415 Student Associates were enrolled

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For further news of Mining Branch membership activities, see page 239.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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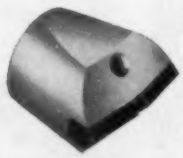
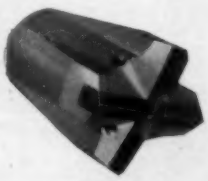


Style PA

Style PC



Style PX

INDUSTRY AND KENNAMETAL ...Partners in Progress

Coming Events

Feb. 7-9, Colorado Mining Assn., Denver.

Feb. 24-28, AIME Annual Meeting, Roosevelt and Jung Hotels, New Orleans.

Mar. 10-16, EJC Second Nuclear Engineering and Science Congress, Convention Hall, Philadelphia.

Mar. 21, AIME Utah Local Section. Speaker: W. Don Quigley, Consulting Geologist; subject: *Discussion of the Aneth and Associated Oil Discoveries in the Paradox Basin.* Newhouse Hotel, Salt Lake City.

Mar. 25-29, ASM, 10th Western Metal Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.

Apr. 1-4, American Assn. of Petroleum Geologists, annual meeting, Kiel Auditorium, St. Louis.

Apr. 5, 6, AIME Pacific Southwest Mineral Industry Conference. Sponsored by Nevada Section, cosponsored by San Francisco and Southern California Sections. Reno.

Apr. 8-10, AIME, National Open Hearth Steel and Blast Furnace, Coke Oven, and Raw Materials Conferences, Penn-Sheraton Hotel, Pittsburgh.

Apr. 10, AIME Utah Local Section, AIME Student Section, University of Utah, dinner meeting. Speaker: A. B. Kinzel, AIME President-Elect; subject: *The New Elements.* Union Hall, University of Utah, Salt Lake City.

Apr. 11-13, AIME, Pacific Northwest Regional Conference, Multnomah Hotel, Portland, Ore.

Apr. 22-24, Second Annual Symposium on Rock Mechanics, Colorado School of Mines, Golden, Colo.

Apr. 22-24, CIM, annual meeting, Ottawa, Ont., Canada.

May 6-8, Institute on Lake Superior Geology, annual meeting, cosponsored by AIME Exploration Subsection, Upper Peninsula Local Section, Michigan Geological Survey, and Michigan Geological Society. Kellogg Center, Michigan State University, East Lansing, Mich.

May 13-16, Coal Convention and Exposition of the American Mining Congress, City Auditorium, Cleveland.

May 16, AIME Utah Local Section. Speaker: A. E. Millar, General Manager, The Anaconda Co., Yerington Mines, Weed Heights, Nev.; subject: *The Yerington Story.* Newhouse Hotel, Salt Lake City.

May 23-24, Lake Superior Mines Safety Council, 33rd annual conference, Hotel Duluth, Duluth.

June 16-21, ASTM, annual meeting, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J.

Sept. 8-Oct. 9, Commonwealth Mining and Metallurgical Congress, British Columbia to Nova Scotia, Canada.

Sept. 9-12, American Mining Congress, annual convention, Utah and Newhouse Hotels, Salt Lake City.

Sept. 18-21, International Mineral Dressing Congress, Royal Inst. of Technology, Stockholm, Sweden.

Oct. 6-9, AIME, Petroleum Branch, Dallas.

Oct. 9-11, ASME-AIME Coal Div., Joint Solid Fuels Conference, Chateau Frontenac, Quebec.

Oct. 15-18, Southeastern Mining Branch Conference, Hillsboro Hotel, Tampa, Fla.

Oct. 30-Nov. 1, AIME, Rocky Moutain Minerals Conference, Denver.

Nov. 4-6, AIME, IMD Fall Meeting, Morrison Hotel, Chicago.

Nov. 11-14, Society of Exploration Geophysicists, 27th Annual Meeting, Statler-Hilton Hotel, Dallas.

Dec. 1-6, ASME, Annual Meeting, Hotel Statler, New York.

Dec. 4-6, AIME, Electric Furnace Steel Conference, Penn-Sheraton Hotel, Pittsburgh.

Feb. 16-20, 1958, AIME Annual Meeting, Hotel Statler, New York.

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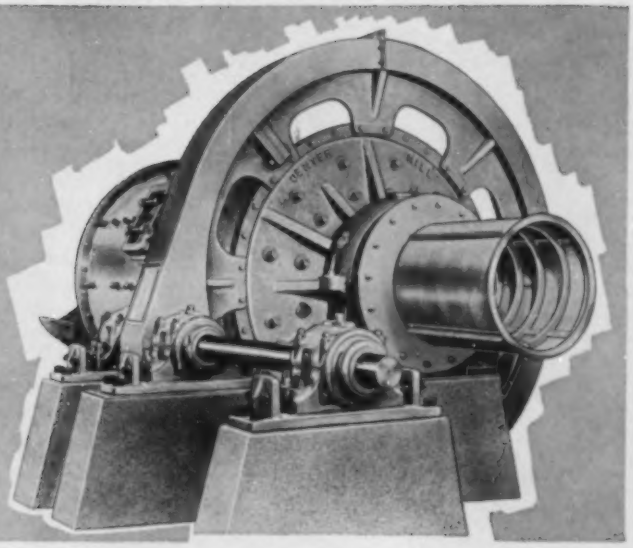

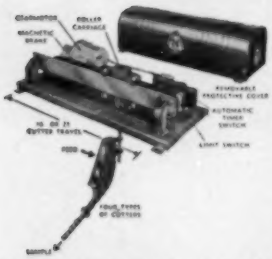

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